Benthic TMDL for Hurricane Branch Unnamed Tributary, Virginia

Submitted by

Virginia Department of Environmental Quality

Prepared by

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. An unnamed tributary (UT) to Hurricane Branch was included on Virginia's 2002 303(d) TMDL Priority List and Report (DEQ, 2002) because of violations of the General Standard (benthic impairment). Hurricane Branch (UT) is located in the south central region of Virginia in Nottoway County (Figure 1-1). It is a tributary of Hurricane Branch in the Nottoway River Basin (Hydrologic Unit 03010201).

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Bioassessments of the benthic macroinvertebrate community of Hurricane Branch (UT) were performed by DEQ using the EPA Rapid Bioassessment Protocols. Results of bioassessments indicated a moderately impaired benthic community at one monitoring station on the creek (Station AXBL000.80). Therefore, since the creek only partially supports the designated aquatic life use, the General Standard for the creek is being violated. As a result, Hurricane Branch (UT) was included on the 303(d) list. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

The listed segment, which is about 1.12 miles in length, begins at the Town of Blackstone Sewage Treatment Plant (STP) and extends downstream to the confluence of the unnamed tributary with Hurricane Branch. Station AXBL000.80 is located on the impaired segment at river mile 0.80, below the Blackstone STP.

Watershed Characterization and Environmental Monitoring

The Hurricane Branch (UT) watershed is approximately 1,980 acres. Forested lands (57.5%) and developed lands (34.2%) represent the two primary land uses in the watershed. The watershed is part of the Piedmont ecoregion which comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. The soils in the watershed are comprised of the Appling-Wedowee-Louisburg soils series. Appling-Wedowee-Louisburg soils are gently sloping to steep, well-drained soils characterized as the type 'B' hydrologic soils group.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) that is impacting the benthic community of Hurricane Branch (UT). Available monitoring data included biological assessments, water quality monitoring data, and Discharge Monitoring Reports (DMR) for permitted facilities in the watershed. Biological monitoring data from 1991 to 2002 were analyzed. Instream water quality conditions were assessed primarily based on field data collected during biological monitoring surveys and results from toxicity testing. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the permitted discharge facilities in the watershed.

Stressor Identification

The primary stressor to Hurricane Branch (UT) was determined based on evaluations of candidate stressors that potentially could be impacting the creek. The 303(d) fact sheet indicated that "erosion and sedimentation problems and the Town of Blackstone Municipal STP discharge" were possible sources of the impairment to the creek. Therefore, sedimentation and hydrologic alteration were evaluated as candidate stressors along with other typical stressors including organic matter, temperature, pH, and toxics. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed.

Although impairment problems initially were attributed in part to the effluent discharge from the Blackstone STP, an evaluation of recent DMR data indicated that the treatment plant has been in compliance for its monitored parameters and does not appear to be adversely impacting the creek at this time. Rather, erosion and sedimentation problems are due to elevated levels of non-point source runoff. This assessment is based on recent field observations, biological assessments, and land use data for the watershed. Developed lands throughout the watershed represent the primary source of non-point source runoff. Impervious surfaces associated with developed lands have led to increased stormwater runoff which, in turn, has contributed to elevated stream flows. This altered hydrology causes stream erosion and sedimentation problems that degrade benthic macroinvertebrate habitat. In addition, elevated stream flows are capable of scouring and flushing out benthic macroinvertebrate populations, as well the habitat in which they live.

Restoration of the benthic community in Hurricane Branch (UT) is largely dependent upon the management of uncontrolled stormwater runoff associated with developed lands throughout the watershed. Management of non-point source runoff should alleviate stream erosion and sedimentation problems and, subsequently, improve benthic macroinvertebrate habitat. It should be noted that the Fort Pickett military base is in the process of developing a new facility master plan which includes provisions for stormwater control. The implementation of such a comprehensive stormwater management plan would have direct and positive impacts on the Hurricane Branch (UT) watershed.

Sediment was selected as a surrogate parameter to represent the instream erosion and sedimentation problems caused by hydrologic alteration. Therefore, a sediment TMDL was developed for Hurricane Branch (UT).

Reference Watershed Approach

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for Hurricane Branch (UT).

Twittys Creek, located in Charlotte County, Virginia, was selected as the reference watershed for the Hurricane Branch (UT) TMDL development. The reference watershed was delineated at DEQ biomonitoring station ATWT008.59, which has served as a non-impaired reference station. Reduction of sediment loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for Hurricane Branch (UT).

Sediment Loading Determination

Sediment sources within the Hurricane Branch (UT) watershed include both point and non-point sources. Point sources include solids loading from permitted discharge facilities. Non-point sources include sediment derived from the erosion of lands present throughout the watershed, washoff from impervious surfaces, and the erosion of stream banks within Hurricane Branch (UT).

Sediment loadings were determined for both the Hurricane Branch (UT) and Twittys Creek watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Hurricane Branch (UT). Sediment loadings from land erosion were determined using Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1990 to 2002 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of Hurricane Branch (UT). Average annual sediment loads were computed for each land source based on the 12 year simulation period. In addition, average annual sediment loads from instream bank erosion and point sources were determined. Point source loadings were computed based on the permitted discharge loading rate for total suspended solids. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003).

Under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Twittys Creek reference watershed is larger than the Hurricane Branch (UT) watershed, reference watershed parameters were adjusted to reflect the size of the impaired watershed. Sediment loadings computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Sediment TMDL allocations for Hurricane Branch (UT) were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:
TMDL= Sediment Load of the Adjusted Reference Watershed
WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of sediment loadings. An explicit margin of safety of 10% was used for Hurricane Branch (UT).

The total wasteload allocated to the Blackstone STP was based on the permitted discharge loading rate for total suspended solids. Load allocations for non-point sources were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural and developed lands and instream erosion by 67%, the sediment TMDL endpoint is achieved. The TMDL for Hurricane Branch (UT) is shown in Table E-1 and the recommended TMDL allocations and the percent reduction required for all watershed sources are presented in Table E-2.

Table E-1: Sediment TMDL for Hurricane Branch (UT) (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
144.5	69.1	60.9	14.5

Table E-2: Recommended TMDL Allocations for Hurricane Branch (UT)

Source	Land Use Type	Hurricane Branch (UT) Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	4.4	4.4	0
	Evergreen Forest	1.7	1.7	0
	Mixed Forest	3.4	3.4	0
	Pasture/Hay	25.7	8.4	67
	Low Intensity Residential	2.3	0.8	67
	Commercial/Industrial	102.7	33.8	67
	Open Water	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
Instream Erosion	-	50.7	16.7	67
Point Sources	-	60.9	60.9	0
Total		251.7	130.0	48

Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

Public Participation

Watershed stakeholders had opportunities to provide input and to participate in the development of the TMDL. Two public meetings were held in the Town of Blackstone, Virginia. The first meeting was held on November 13, 2003, and the second meeting was held on March 2, 2004.

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1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency (EPA)'s Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to better develop and regulate a more effective TMDL process. The role of DEQ is to act as a lead agency for the development of statewide TMDLs. DEQ focuses its efforts on all aspects of pollution reduction and prevention to the state waters. DEQ ensures compliance with the Clean Water Act and the Water Quality Planning Act, as well as encourages public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs on a statewide level through the use of grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits from industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (DEQ, 2001a).

As required by the Clean Water Act, Virginia DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) in violation and the potential source(s) of each pollutant. This list is commonly referred to as the 303(d) list. The

Water Quality Monitoring Information and Restoration Act was passed in 1997 by the Virginia General Assembly to guide DEQ in creating and implementing TMDLs for the state waters on the 303(d) list (DEQ, 2001a). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

An unnamed tributary (UT) to Hurricane Branch was initially included on Virginia's 1994 303(d) list (DEQ, 1994) because of water quality violations of the General Standard (benthic impairment). Hurricane Branch (UT) was subsequently listed on the 1996 303(d) TMDL Priority List (DEQ, 1996), the 1998 303(d) Total Maximum Daily Load Priority List and Report (DEQ, 1998), and the 2002 303(d) Report on Impaired Waters (DEQ, 2002). Biological assessments conducted at DEQ monitoring station AXBL000.80 indicated a moderately impaired benthic macroinvertebrate community resulting in the 303(d) listing.

Hurricane Branch (UT) is located in the south central region of Virginia in Nottoway County (Figure 1-1). It is a tributary of Hurricane Branch in the Nottoway River Basin (Hydrologic Unit 03010201). The listed segment, which is about 1.12 miles in length, begins at the Town of Blackstone Sewage Treatment Plant and extends downstream to the confluence of the unnamed tributary with Hurricane Branch. A map of the listed segment for Hurricane Branch (UT) is displayed in Figure 1-2.

Figure 1-1: Location of the Hurricane Branch (UT) Watershed

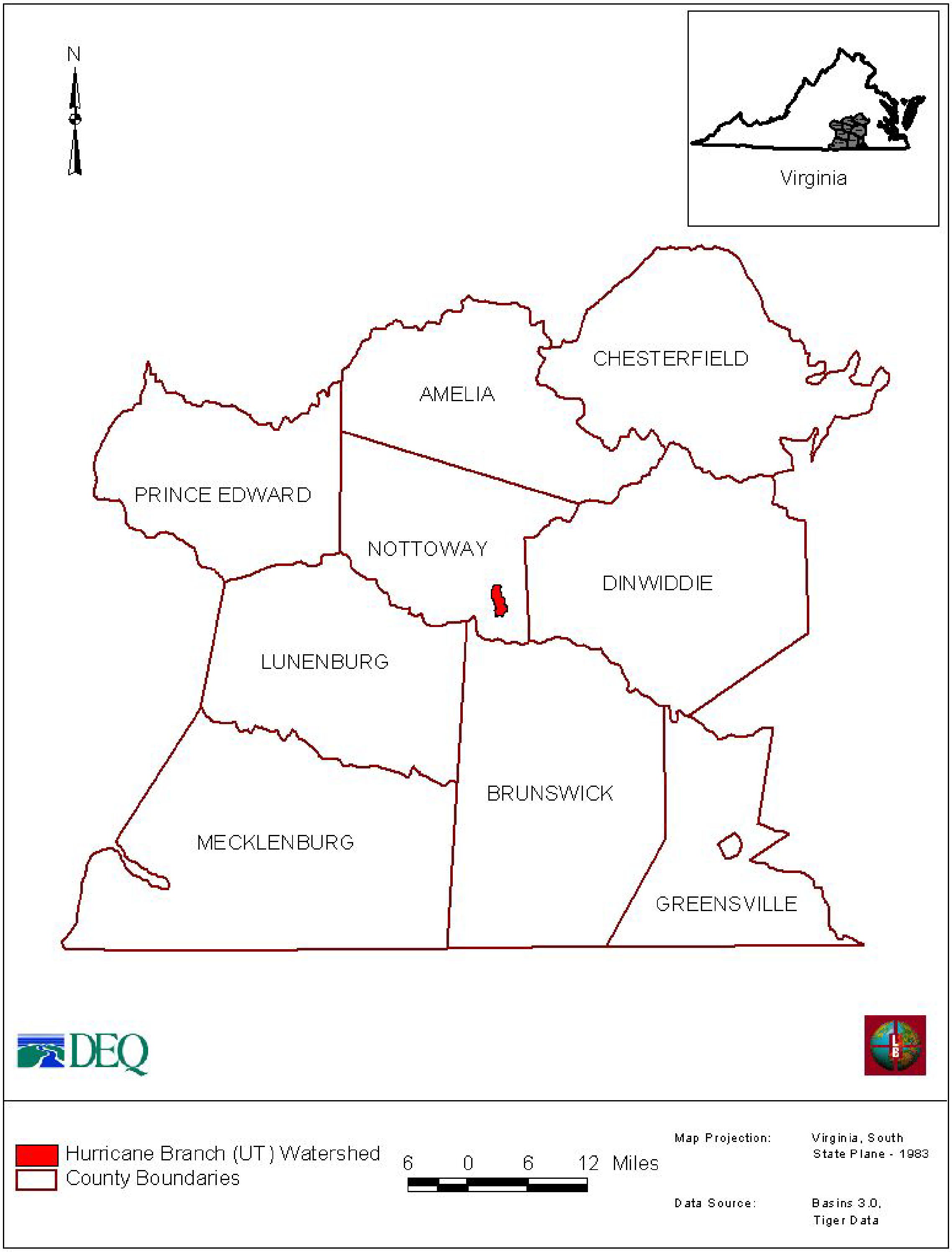
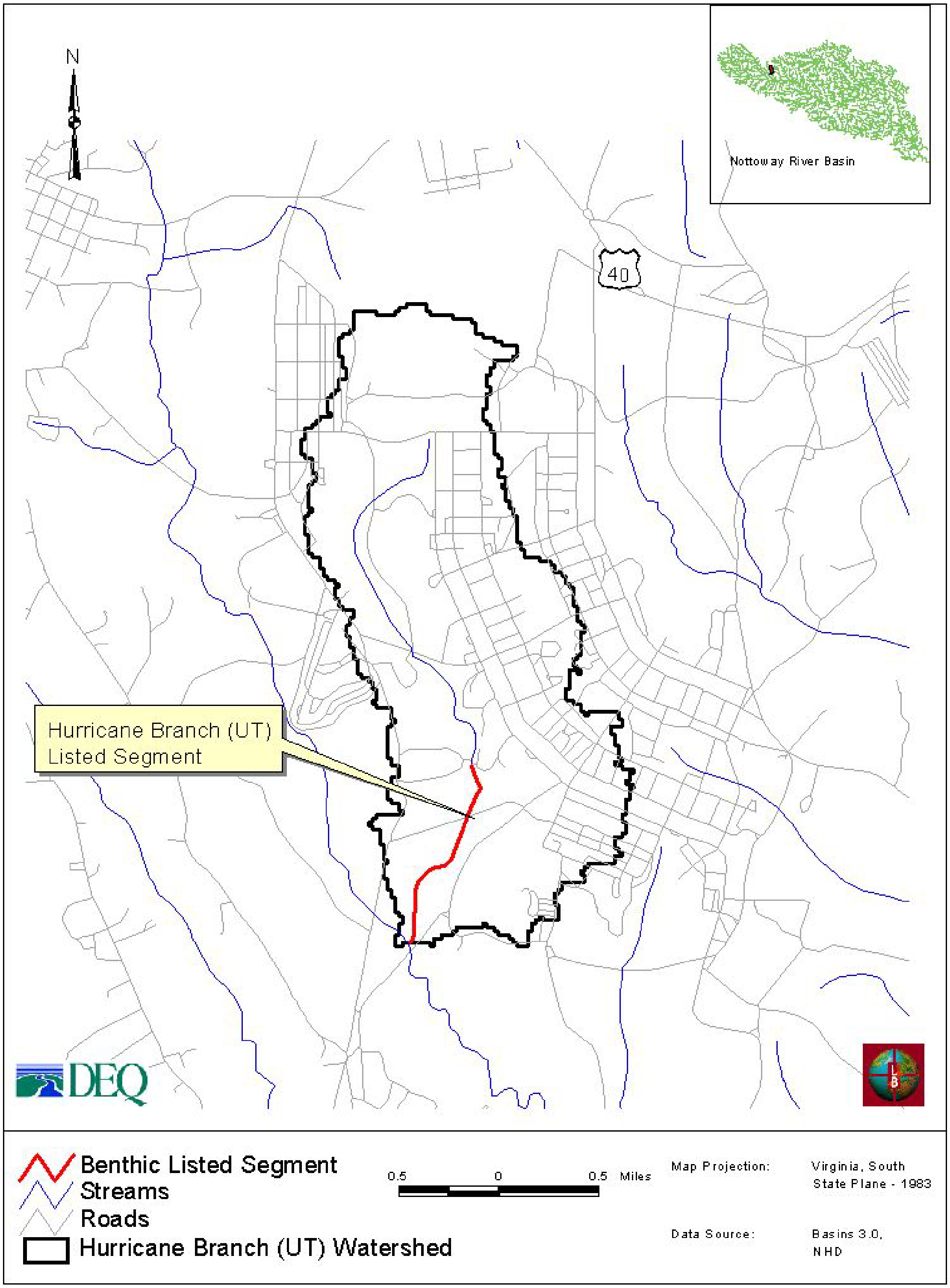


Figure 1-2: Hurricane Branch (UT) Listed Segment



1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *water quality standards* "means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

The listed segment of Hurricane Branch (UT) only partially supports the aquatic life use for the creek based on the moderate impairment of the benthic community determined in biological assessments.

1.3.2 Water Quality Criteria

The General Standard defined in Virginia Water Quality Standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standard states:

> *"All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

The biological assessments performed for Hurricane Branch (UT) indicate that some pollutant(s) are interfering with attainment of the aquatic life use for the creek. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

1.4 TMDL Development for Hurricane Branch (UT)

TMDL development for benthic impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow the stream to attain its designated use. In the subsequent sections of this report, watershed and environmental monitoring data used in the Hurricane Branch (UT) TMDL development are discussed. Pollutants, also called *stressors*, which may be impacting the creek, are then analyzed in the stressor identification section. Based on this analysis, a primary stressor impacting the creek is identified. A technical approach used to estimate mass loading rates of the primary stressor to the creek is presented. In addition, the methodology used to quantify load reductions necessary to obtain designated uses is described. Finally, the TMDL allocations for Hurricane Branch (UT) are presented and TMDL implementation is discussed.

2.0 Watershed Characterization

Hurricane Branch (UT) watershed physical conditions were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the watershed characterization was to provide an overview of the conditions in the watershed related to the benthic impairment of Hurricane Branch (UT). Information contained in the watershed GIS was used in identifying potential pollutant(s) causing the impairment as well as for the subsequent TMDL development. In particular, watershed physical features such as topography, soils types, and the land use types were characterized. In addition, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the Hurricane Branch (UT) watershed were analyzed using GIS coverages developed for the watershed. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

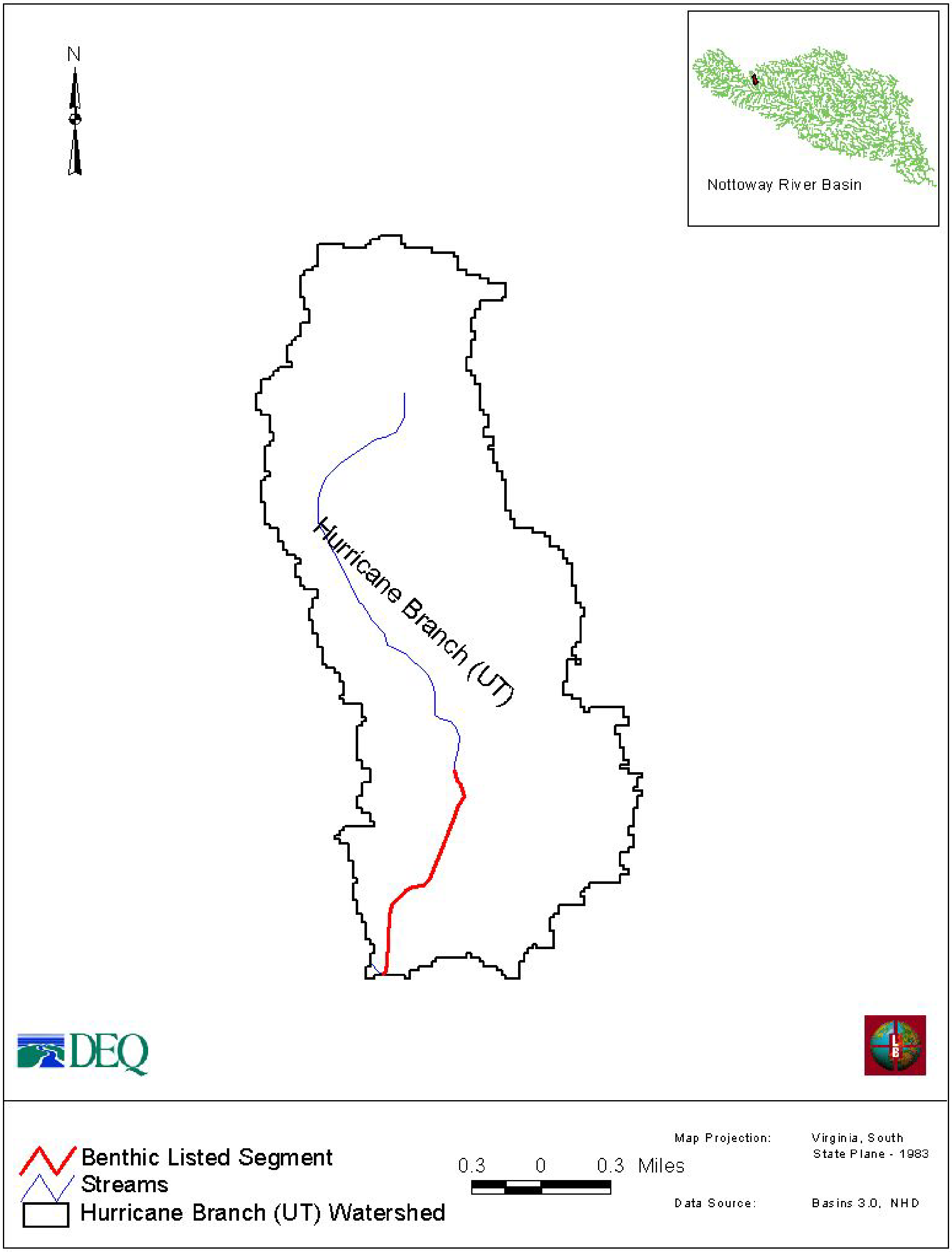
2.1.1 Watershed Location and Boundary

The Hurricane Branch (UT) watershed, located in Nottoway County, Virginia, is approximately 1,985 acres or 3.1 square miles. The delineated watershed boundary is shown in Figure 1-2. The watershed includes lands in the eastern area controlled by the Fort Pickett Military Base and lands in the northern headwaters controlled by the Nottoway County Local Reuse Authority.

2.1.2 Stream Network

The stream network for the Hurricane Branch (UT) watershed was obtained from BASINS Reach File 3 (RF3) and the National Hydrography Dataset (NHD). Figure 2-1 displays a map of the streams including the benthic impairment listed segment.

Figure 2-1: Stream Network for the Hurricane Branch (UT) Watershed



2.1.3 Topography

A digital elevation model (DEM) and USGS 7.5 minute quadrangle maps were used to characterize topography in the watershed. DEM data were obtained from BASINS and compared to the Nottoway County, Virginia USGS 7.5 minute quadrangle maps. Elevation in the watershed ranged from 225 to 447 feet above mean sea level with an average of 333 feet.

2.1.4 Soils

The Hurricane Branch (UT) watershed soil characterization was based on the State Soil Geographic (STATSGO) Database for Virginia. The Appling-Wedowee-Louisburg soil association is the dominant soil type Hurricane Branch (UT) watershed. Theses soils are gently sloping to steep, well-drained soils that are derived from granite, gneiss, and schist. A summary of the soil characteristics in the Hurricane Branch (UT) watershed is presented in Table 2-1.

Table 2-1: Soil Types and Characteristics in the Hurricane Branch (UT) Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA030	Appling-Wedowee-Louisburg	100	B
Source: State Soil Geographic (STATSGO) Database for Virginia			

The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in Table 2-2.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

2.1.5 Land Use

Land use characterization was based on National Land Cover Data (NLCD) developed by USGS. The distribution of land uses in Hurricane Branch (UT), by land area and percentage, is presented in Table 2-3. The table indicates that forested lands (57.5%) and developed lands (34.2%) represent the two primary land uses in the watershed. Brief descriptions of land use classifications are presented in Table 2-4. Figure 2-2 displays a map of the land uses within the watershed. Developed lands are associated primarily with the northern and eastern areas of the watershed. Forested lands predominate in the southern and western areas of the watershed.

Table 2-3: Hurricane Branch (UT) Watershed Land Use Distribution

Land Use Category	NLCD Land Use Type	Acres	Percentage of Watershed	Total Percent
Forested	Deciduous Forest	529.5	26.7	57.5
	Evergreen Forest	205.2	10.3	
	Mixed Forest	405.9	20.5	
Agricultural	Pasture/Hay	162.4	8.2	8.2
Developed	Low intensity residential	458.4	23.1	34.2
	Commercial/Industrial	220.9	11.1	
Water/Wetlands	Open water	0.9	0.0	0.1
	Emergent Herbaceous	1.3	0.1	
Total		**1,985**	**100.0**	**100.0**

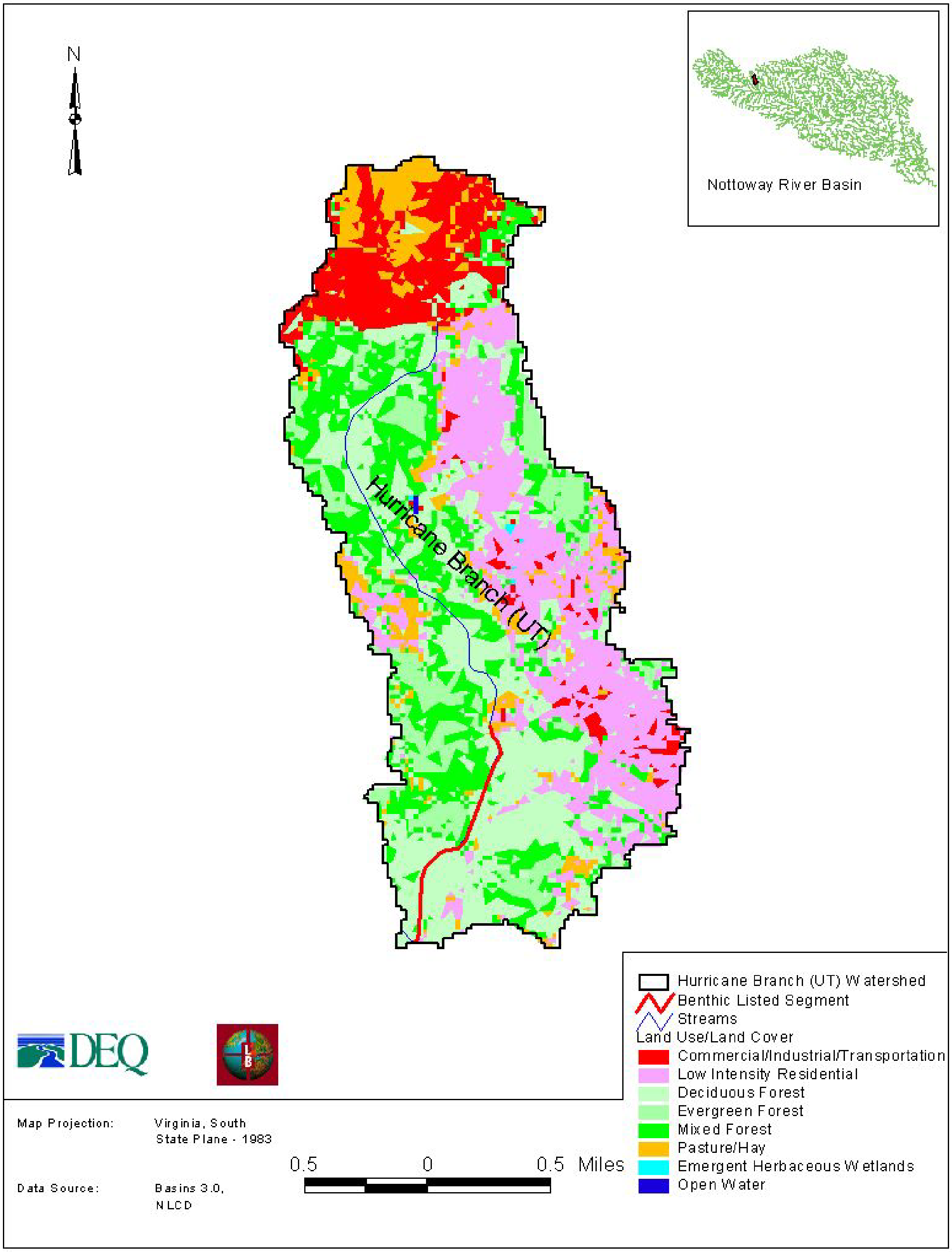
Source: National Land Cover Data (NLCD)

Table 2-4: Descriptions of NLCD Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
Commercial/Industrial/Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Source: National Land Cover Data (NLCD)

Figure 2-2: Land Use in the Hurricane Branch (UT) Watershed



2.1.6 Ecoregion Classification

Hurricane Branch (UT) is located within the Piedmont ecoregion, Level III classification number 45 (Woods et al., 1999). This ecoregion extends from Wayne County Pennsylvania southwest through Virginia, and comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. Once largely cultivated, much of this region has reverted to pine and hardwood woodlands. The Piedmont ecoregion is characterized by shallow valleys, irregular plains, and low rounded hills and ridges. The underlying geology of this region consists of deeply weathered, deformed metamorphic rocks with intrusions by igneous material. The location of the Hurricane Branch (UT) watershed within the Piedmont ecoregion is displayed in Figure 2-3.

2.2 Permitted Discharge Facilities

There are two permitted facilities in the watershed that discharge into Hurricane Branch (UT); these are the Town of Blackstone Sewage Treatment Plant (STP) and Water Treatment Plant (WTP). Facility permit numbers, design flows, and status are presented in Table 2-5. A map of the permitted facilities is presented in Figure 2-4. The Blackstone WTP recently began routing its discharge to the Blackstone STP and no longer discharges to the Hurricane Branch (UT) except for emergencies. The Blackstone STP was upgraded in 2000 in order to meet a compliance schedule for permitted discharge of ammonia.

Table 2-5: Permitted Discharge Facilities in the Hurricane Branch (UT) Watershed

Permit Number	Facility Name	Design Flow (gpd)[a]	Status
VA0025194	Blackstone STP	2,000,000	Active
VA0005827	Blackstone WTP	Not Applicable [b]	Active

a: Gallons per day
b: Effluent from the Blackstone WTP is currently routed to the Blackstone STP for treatment

Figure 2-3: Virginia Level III Ecoregions

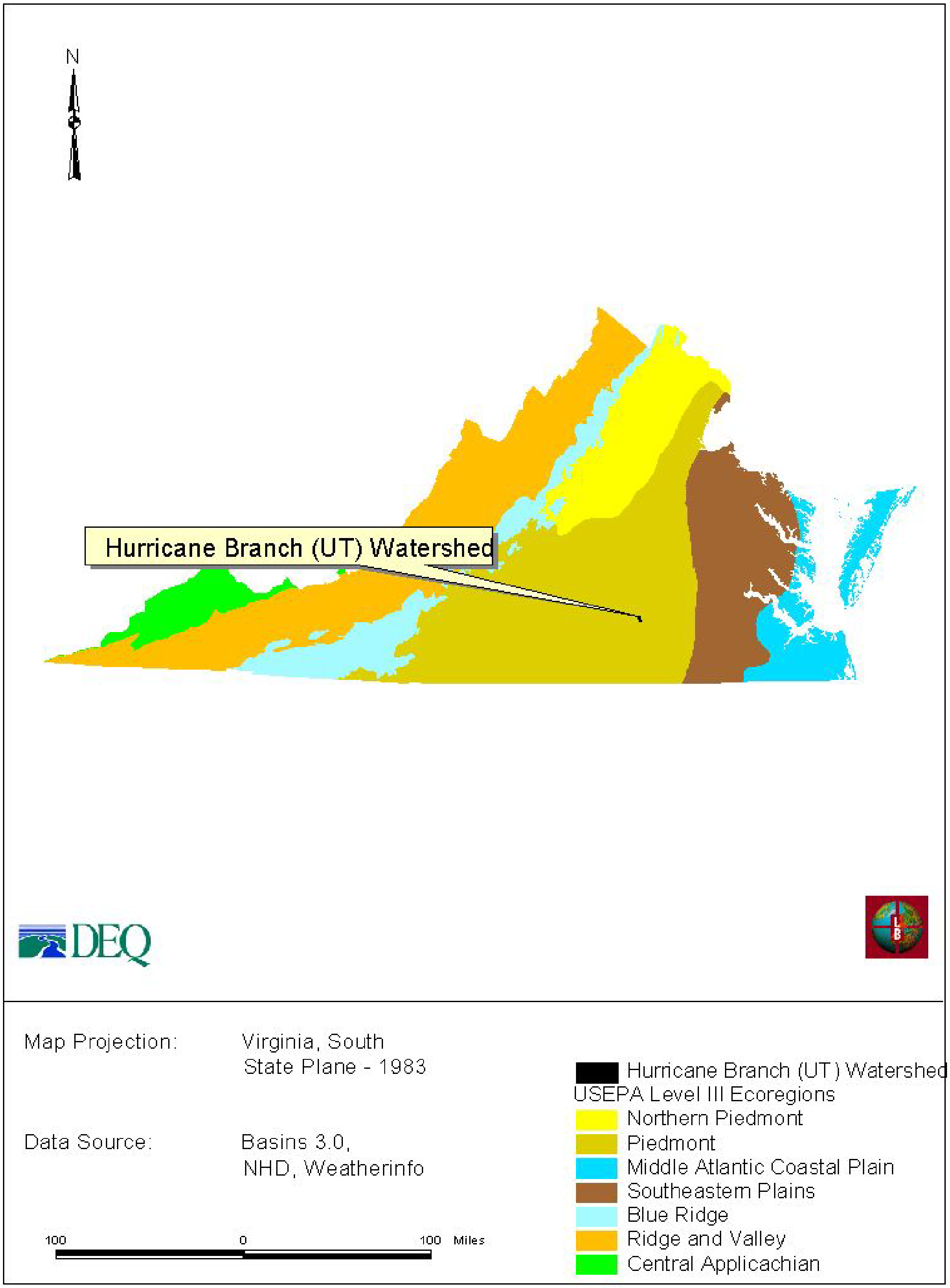
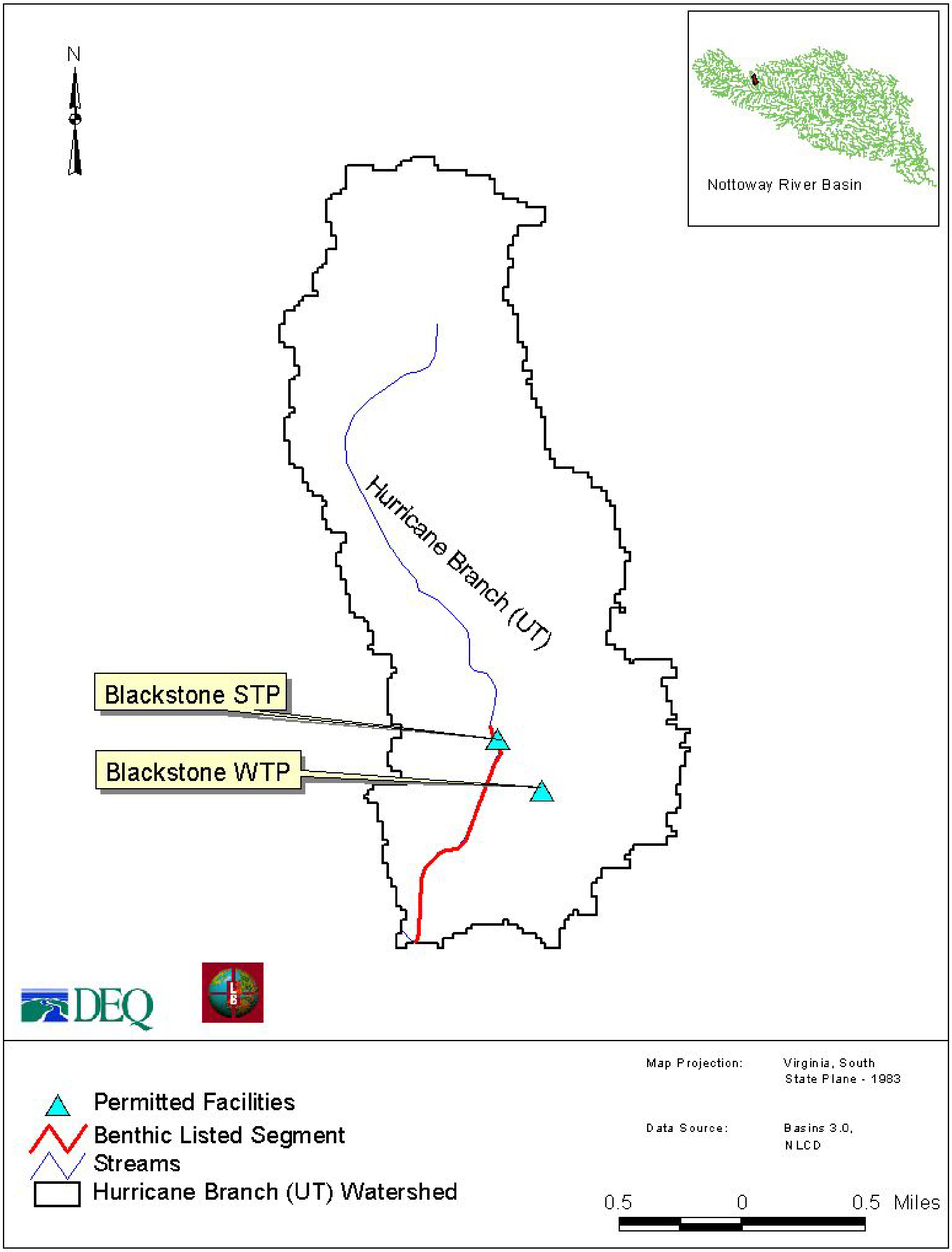


Figure 2-4: Location of Permitted Discharge Facilities in Hurricane Branch (UT)



2.3 DEQ Monitoring Stations

DEQ has two monitoring stations on Hurricane Branch (UT) which are used for biological monitoring. No water quality monitoring stations are present in the Hurricane Branch (UT) watershed. A summary list of the DEQ monitoring stations located in the Hurricane Branch (UT) watershed is presented in Table 2-6 and station locations are presented in Figure 2-5. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek.

Table 2-6: Summary of DEQ Monitoring Stations

Station Id	Station Type	Period Of Record	Note
AXBL000.80	Biological monitoring	1990-1997, 2002	Recovery station
AXBL001.18	Biological monitoring	1990-1997, 2002	Reference station

Station AXBL000.80 is the biological monitoring station on the creek that is impaired based on DEQ bioassessments. Station AXBL001.18 is the biological monitoring station that was used as the reference station for bioassessments. Bioassesment data and results are described in detail in Section 3.0.

2.4 Overview of Hurricane Branch (UT) Watershed

The dominant land uses in the UT Hurricane branch are forested land which make up about 58 percent and developed or urban lands which make up about 34 percent of the watershed land area. There are two permitted discharge facilities, the Blackstone STP and the Blackstone WTP. There are two biological monitoring stations in the Hurricane Branch (UT) watershed. The land use and the location of the permitted discharge facilities and monitoring stations are shown in relation to the benthic impairment segment in the summary map provided in Figure 2-6. Station AXBL000.80 is located downstream of the Blackstone STP outfall.

Figure 2-5: DEQ Monitoring Stations in the Hurricane Branch (UT) Watershed

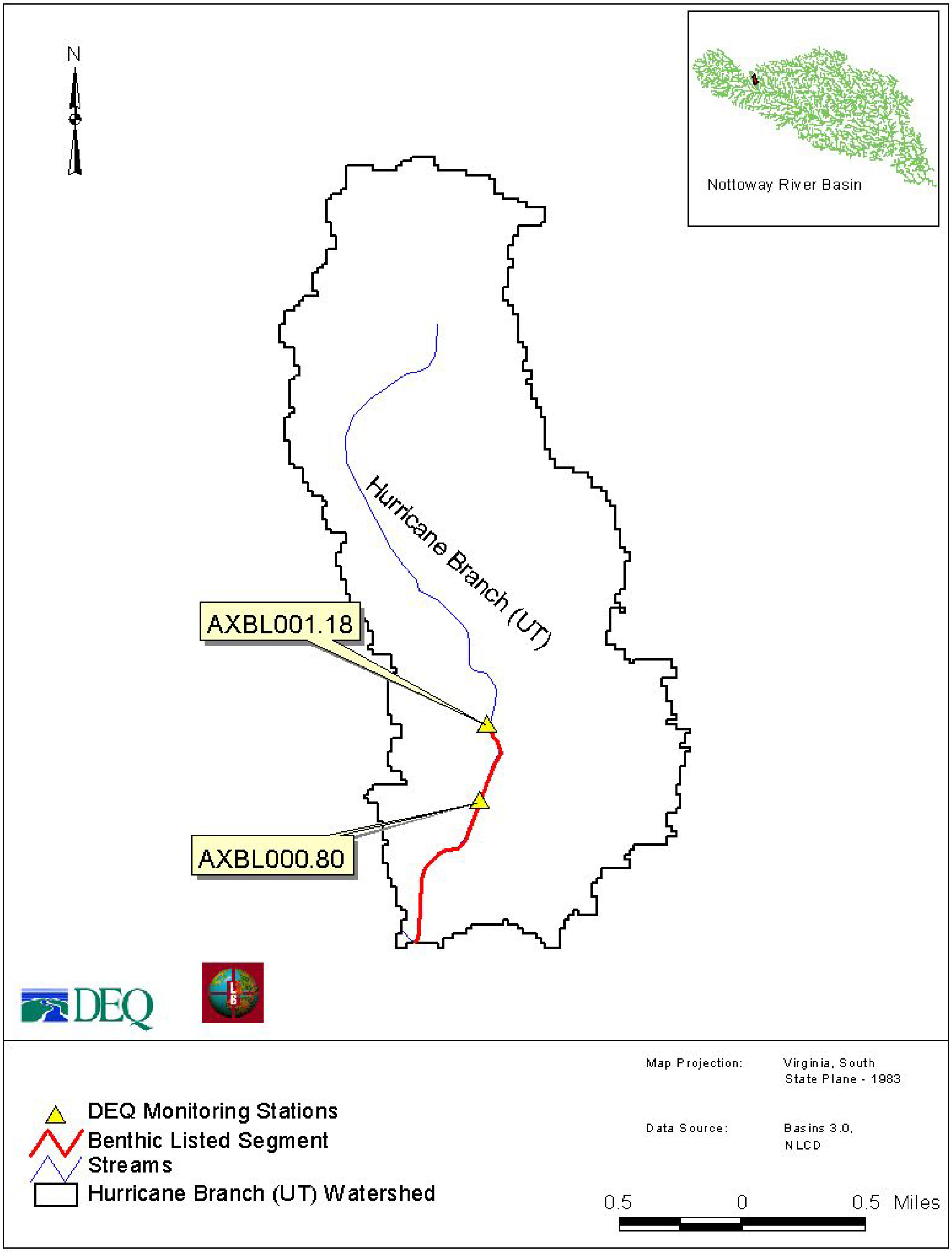
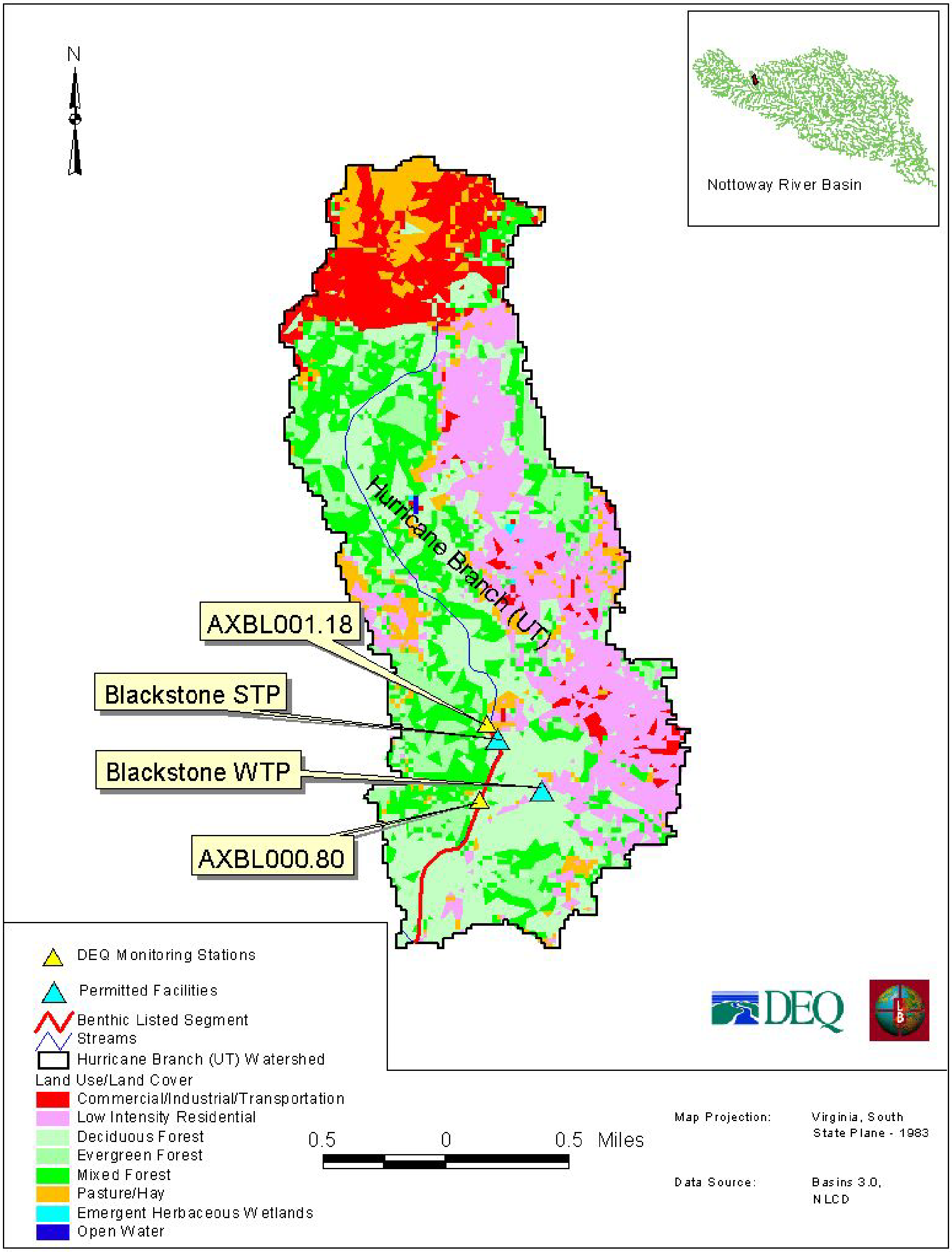


Figure 2-6: Overview of the Hurricane Branch (UT) Watershed



3.0 Environmental Monitoring

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is impacting the benthic community in the waterbody. Environmental monitoring data are vital to this initial step. The following sections summarize and present monitoring data collected and used in the TMDL development for Hurricane Branch (UT). Analyzed data sources included available biological and water quality monitoring data measured since 1991 and Discharge Monitoring Reports for permitted facilities in the watershed. The collection period, content, and monitored sites for these data sources are summarized in Table 3-1. The locations of permitted discharge facilities and monitoring stations were presented previously in Figures 2-4 and 2-5.

Table 3-1: Inventory of Environmental Monitoring Data for Hurricane Branch (UT)

Data Type	Collection Period	Description	Monitored Stations		Blackstone STP	Blackstone WTP
			AXBL000.80	AXBL001.18		
DEQ Biological Monitoring	1991 – 1997, 2002	Field data sheets and bioassessments forms completed during biomonitoring surveys	X	X		
DEQ Field Water Quality Monitoring	1991 – 1997, 2002	Field water quality parameters measured during biomonitoring surveys	X	X		
DEQ Toxicity Study	April 2003	Chronic toxicity testing using Hurricane Branch (UT) stream samples	X			
Discharge Monitoring Reports (DMR)	1999 – 2003	Monthly effluent discharge values for permitted facilities			X	X

3.1 Biological Monitoring Data

Hurricane Branch (UT) was included on the 2002 Virginia 303(d) list based on biomonitoring results obtained for a 5 year assessment period between January 1996 and December 2000. A modified version of the EPA Rapid Bioassessment Protocols II (RBPII) was used to assess the biological condition of the benthic community in the creek. Bioassessments followed a paired reference approach using upstream stations located in the same watershed. The protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures.

The benthic community at station AXBL000.80 was assessed as moderately impaired based on comparison with an upstream reference station. Station AXBL000.80 is a recovery station located downstream of the Blackstone STP (Figure 2-6). The reference station, AXBL001.18, is located immediately upstream of the treatment plant.

3.1.1 Field Data Sheets and Bioassessment Forms

DEQ field data sheets and bioassessment forms used for the biomonitoring stations on Hurricane Branch (UT) contained the following information:

- Assessment ratings for each station for each survey event
- Field notes from the DEQ biologist conducting the surveys
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of the each survey
- The numbers and types of macroinvertebrates present at each station

3.1.1.1 Bioassessment Ratings

The benthic community at station AXBL000.80 has been assessed as moderately or severely impaired since 1991. A summary of assessment ratings is presented in Table 3-2. The benthic impairment status generally shifted from severe to moderate in the mid 1990's.

Table 3-2: Summary of Biomonitoring Assessments for Hurricane Branch (UT)

Year	Season	Assessment Rating*
		AXBL00.80
1991	Fall	MI
1992	Spring	SI
1992	Fall	MI
1993	Spring	SI
1993	Fall	SI
1994	Spring	SI
1994	Fall	SI
1995	Spring	MI
1996	Spring	MI
1996	Fall	MI
1997	Spring	MI
1997	Fall	MI
2002	Spring	MI
2002	Fall	MI
*MI = Moderately Impaired, SI = Severely Impaired		

3.1.1.2 Field Notes

A review of notes contained in the field data sheets indicated the following:

- Construction of dechlorination facilities at the Blackstone STP caused severe erosion and sedimentation problems in the creek, beginning in 1991.
- Also in 1991, "solids deposits in the stream from the STP in-plant operations also a problem."
- Both the reference and impaired stations are "habitat limiting due to the predominant sand substrate."
- Typically, leaf packs represented the most productive habitat at both stations, and therefore served as the primary source for benthic sampling.
- Increased sand deposits from non-point sources were observed upstream in 1994.

3.1.1.3 Habitat Assessment Scores

Overall habitat assessment scores were comparable at the reference and impaired stations.

Habitat scores are presented in Table 3-3.

Table 3-3: Habitat Scores for Reference and Impaired Stations

Station ID	Date	Total Habitat Score	Channel Alteration	Bank Stability	Bank Vegetative Protection	Cover	Substrate Embeddedness
AXBL000.80	11/17/94	164	20	16	14	8	12
	05/31/95	164	20	16	14	8	12
	04/23/96	164	20	16	14	8	12
	11/13/96	164	20	16	14	8	12
	05/13/97	164	20	16	14	8	12
	11/19/97	164	20	16	14	8	12
	05/14/98	164	20	16	14	8	12
	10/01/02	136	20	16	16	10	8
AXBL001.18	11/17/94	135	18	9	10	8	16
	05/31/95	135	18	9	10	8	16
	04/23/96	135	18	9	10	8	16
	11/13/96	135	18	9	10	8	16
	05/13/97	135	18	9	10	8	16
	11/19/97	135	18	9	10	8	16
	11/19/97	135	18	9	10	8	16
	05/14/98	135	18	9	10	8	16
	10/1/02	136	20	14	14	10	10

Table 3-3: Habitat Scores for Reference and Impaired Stations (Continued)

Station ID	Date	Channel Flow	Graze	Riffles	Riparian Vegetative Zone	Sedimentation	Channel Velocity
AXBL000.80	11/17/94	16	18	14	14	10	10
	05/31/95	16	18	14	14	10	10
	04/23/96	16	18	14	14	10	10
	11/13/96	16	18	14	14	10	10
	05/13/97	16	18	14	14	10	10
	11/19/97	16	18	14	14	10	10
	05/14/98	16	18	14	14	10	10
	10/1/02	12	N/A	10	18	14	12
AXBL001.18	11/17/94	7	15	8	18	10	8
	05/31/95	7	15	8	18	10	8
	04/23/96	7	15	8	18	10	8
	11/13/96	7	15	8	18	10	8
	05/13/97	7	15	8	18	10	8
	11/19/97	7	15	8	18	10	8
	11/19/97	7	15	8	18	10	8
	05/14/98	7	15	8	18	10	8
	10/01/02	12	N/A	10	18	14	10

N/A: Data not available

3.1.2 Virginia Stream Condition Index (SCI) Scores

Using the data collected during biomonitoring surveys, biological assessment scores were calculated using the Virginia Stream Condition Index (SCI) currently being developed by DEQ. The SCI is a regionally-calibrated index comprised of eight metrics that are listed in Table 3-4. The metrics used in calculation of an SCI score are similar to the metrics used in RBPII assessments. However, unlike RBPII, the reference condition of the SCI Index is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 60 has been proposed for assessing results obtained with the SCI. Streams that score greater than 60 are considered to be non-impaired, whereas streams that score less than 60 are considered impaired.

Calculated SCI scores for both biomonitoring stations located on Hurricane Branch (UT) are presented in Table 3-5. The average score for the recovery station, AXBL000.80, was 30 for the period of 1994 to 2002. Therefore, this station is considered to be impaired on a regional basis. Since the upstream reference station, AXBL001.18, had an average SCI score of 50 over this same period, it is also considered impaired on a regional basis. Therefore, the stressor responsible for the impairment of the benthic community at the downstream station most likely is also impacting the benthic community at the upstream station, although to a lesser extent.

Table 3-4: Metrics Used in the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/***Diversity***		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Table 3-5: Virginia SCI Scores for Hurricane Branch (UT)

Assessment Date	SCI Score	
	AXBL000.80	**Reference Station***
11/17/94	25	51
05/31/95	14	43
04/23/96	30	55
11/13/96	28	34
05/13/97	24	47
11/19/97	39	60
05/14/98	41	57
06/06/02	30	52
10/01/02	30	51
Average	**30**	**50**
* Station AXBL001.18 served as the reference station.		

3.2 Water Quality Monitoring

3.2.1 Ambient Water Quality Data

No ambient water quality monitoring data are available for the Hurricane Branch (UT) watershed.

3.2.2 Field Water Quality Data from Biomonitoring Surveys

Field measurements for dissolved oxygen, conductivity, pH, and temperature were recorded as part of biomonitoring surveys. Monitoring data, presented in Figures 3-1 to 3-4 indicate there are no significant differences between the reference and recovery stations for temperature and pH. Dissolved oxygen concentrations are slightly higher at the reference station. Conductivity measurements are slightly higher at the recovery station. However, none of the monitored parameters at either station violate numeric criteria for Class III Waters (Nontidal waters) as defined in Virginia Water Quality Standards (9 VAC 25-260-50) (Table 3-6).

Table 3-6: Virginia Water Quality Standards for Class III Waters

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Average		
III	Nontidal Waters (Coastal and Piedmont Zones)	4.0	5.0	6.0-9.0	32

Figure 3-1: Hurricane Branch (UT) Biomonitoring Field Data - Temperature

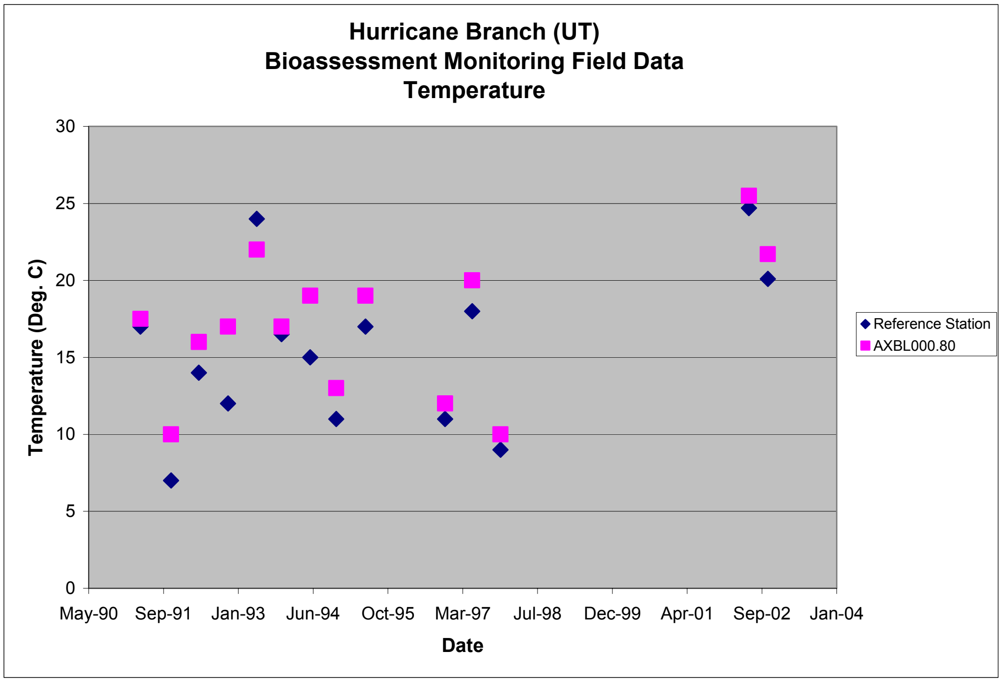


Figure 3-2: Hurricane Branch (UT) Biomonitoring Field Data - Dissolved Oxygen

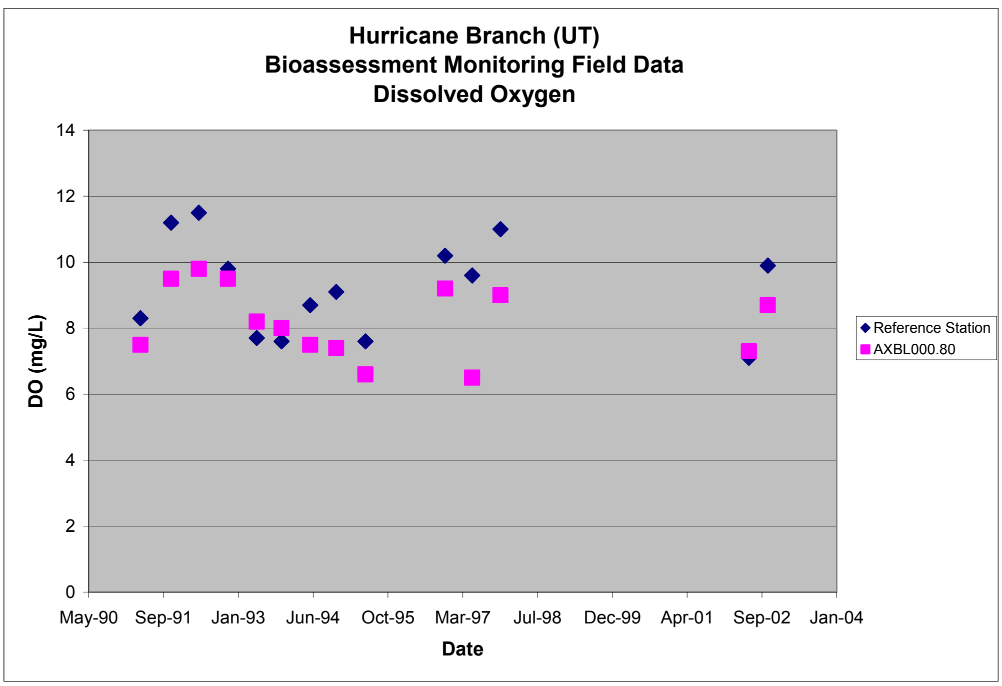


Figure 3-3: Hurricane Branch (UT) Biomonitoring Field Data - Specific Conductivity

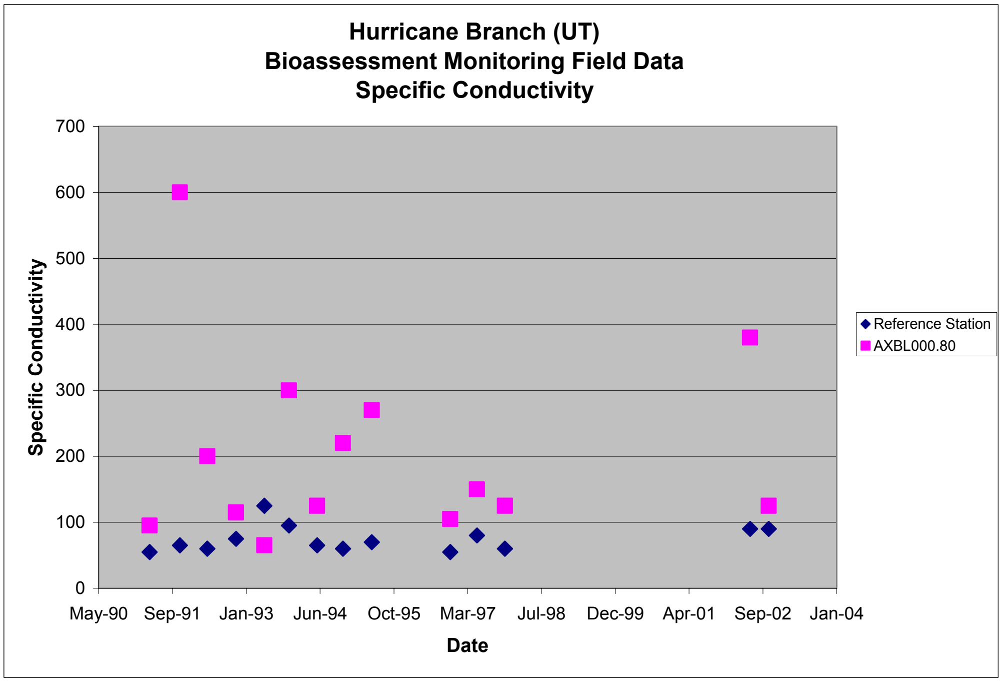
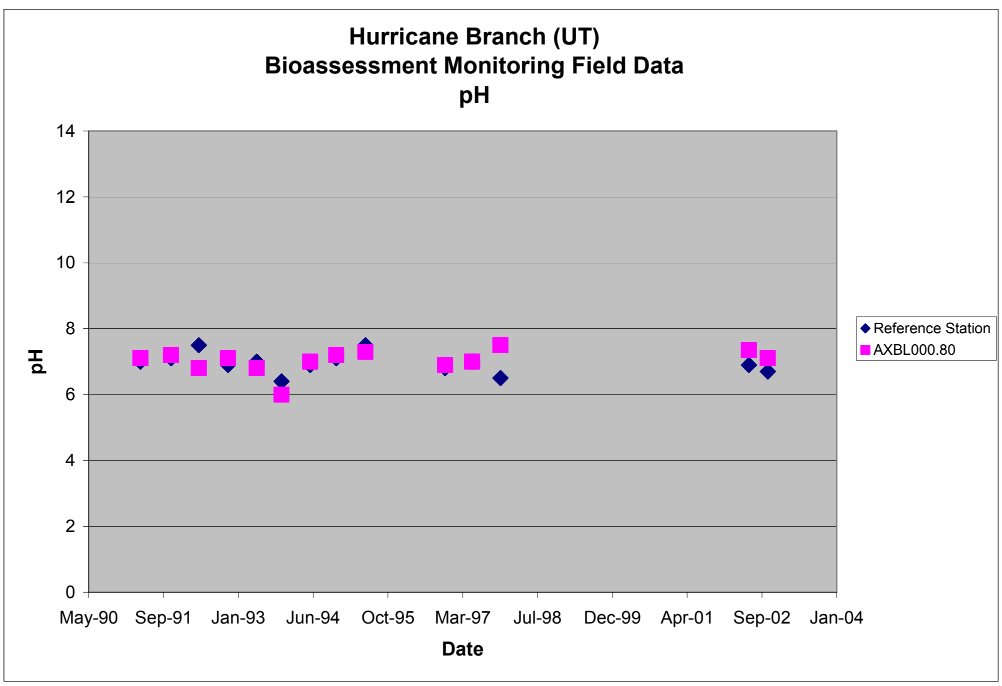


Figure 3-4: Hurricane Branch (UT) Biomonitoring Field Data - pH



3.2.3 Instream Toxicity Testing

Toxicity testing for Hurricane Branch (UT) was performed on water samples collected by DEQ in April, 2003 at station AXBL000.80. The EPA Region 3 Laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and Ceriodaphnia dubia as test organisms. Results indicated no toxic effects to test organisms.

3.3 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for the Blackstone STP and WTP were obtained from DEQ and compared with permitted discharge limits. The level of compliance for permitted discharge parameters is discussed below. Table 3-7 summarizes water quality violations at the Blackstone STP.

- Average monthly values for monitored parameters at the Blackstone STP are shown in Figures 3-5 through 3-13. These data indicate that monitored parameters have been in compliance since 2001. The Blackstone STP was upgraded in 2000, which significantly lowered ammonia concentrations in plant effluent. Since the upgrade, there has been only one violation of the maximum ammonia concentration, and all monthly average ammonia concentrations have been well below the permitted limit of 6.1 mg/L. The maximum ammonia violation was attributed to illegal dumping by a contractor (Silverman, Personal Communication 2002). As shown in Table 3-7, other monitored parameters have also been in compliance since about the time the plant upgrades were completed in 2001. In addition, no violations have been observed for whole effluent toxicity.

- Average monthly values for monitored parameters at the Blackstone WTP are shown in Figures 3-14 and 3-15. These data also indicate that monitored parameters have been in general compliance over the past several years. There have been no violations for total suspended solids and two violations for pH. Recently the Blackstone WTP began routing its effluent to the STP for treatment, and no longer discharges directly into the stream.

Table 3-7: Summary of Blackstone STP Effluent Water Quality Conditions

Water Quality Parameter	Period of record	No. of Violations	Dates
NH3	1999 to 2003	1[a]	Jan 01
BOD5	1998 to 1999	2	Dec 98, Jan 99
CBOD5	1999 to 2003	0	
DO	1999 to 2003	0	
Hardness as CaCO3	1999 to 2003	1	May 00
pH	1998 to 2003	4	Nov 98, Aug 99, Sept 99, June 00
TKN	1999 to 2003	2	July 01, Aug 01
TSS	1999 to 2003	2	Apr 99, Apr 00
a: Violation was attributed to illegal dumping by a contractor.			

Figure 3-5: Blackstone STP - Ammonia

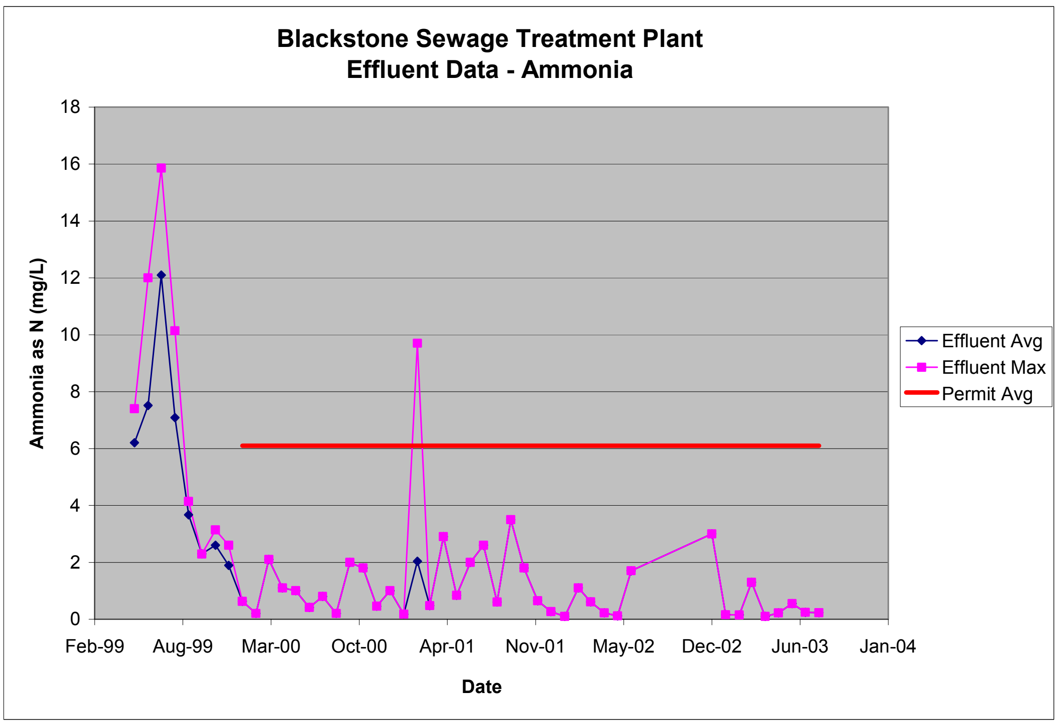


Figure 3-6: Blackstone STP – Biochemical Oxygen Demand

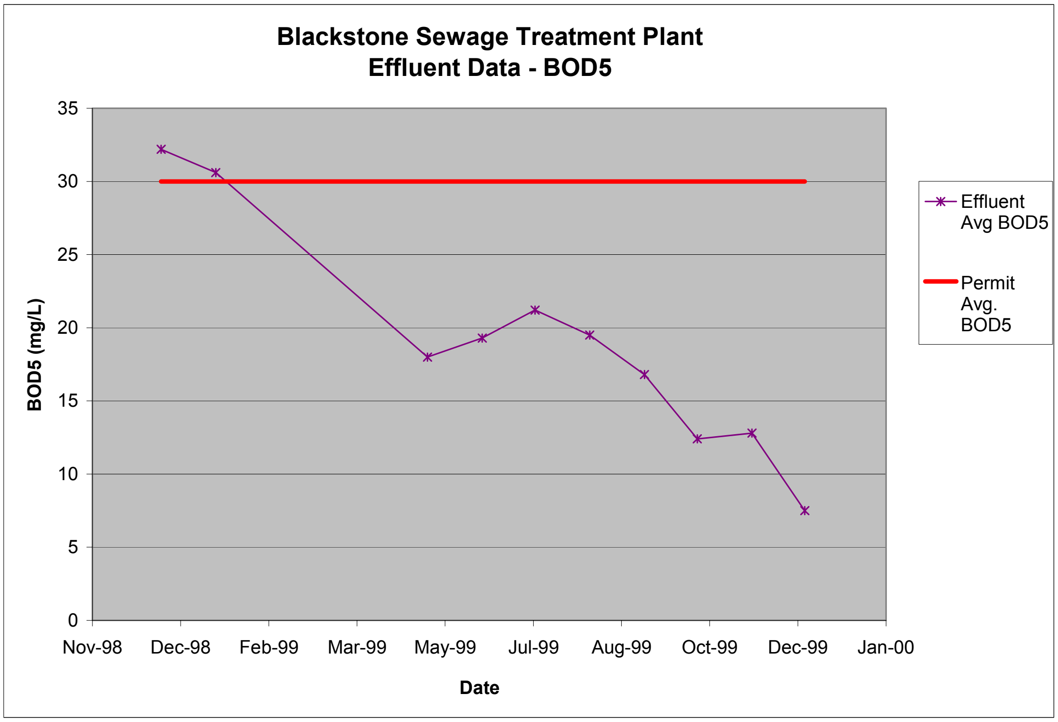


Figure 3-7: Blackstone STP – Carbonaceous Biochemical Oxygen Demand

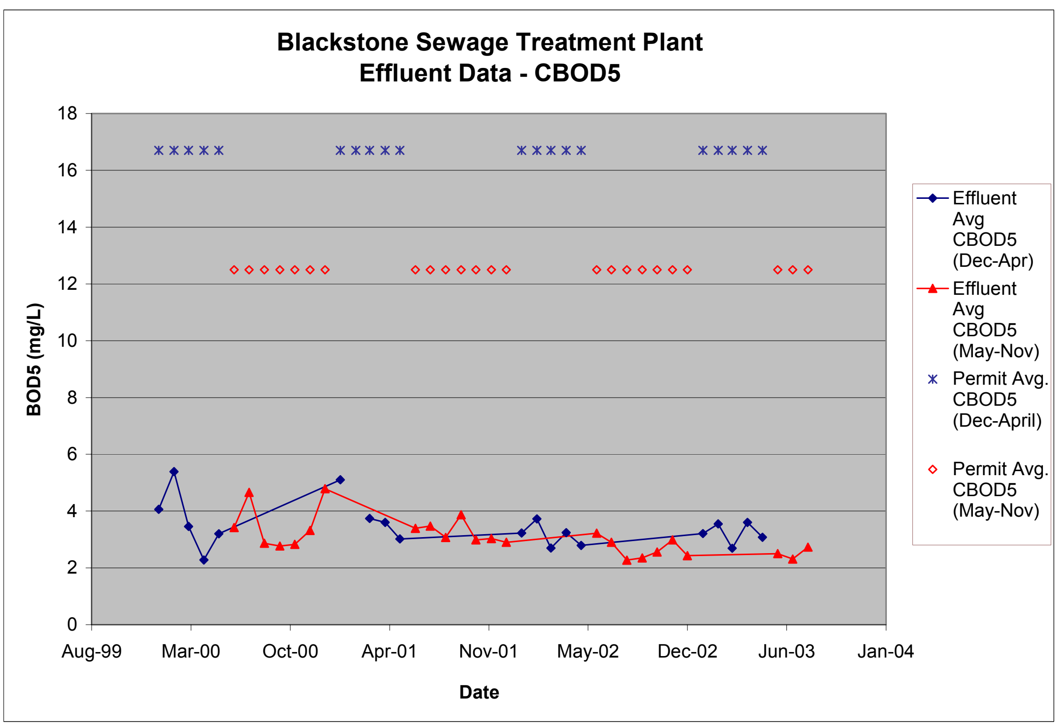


Figure 3-8: Blackstone STP – CL2 Total Contact

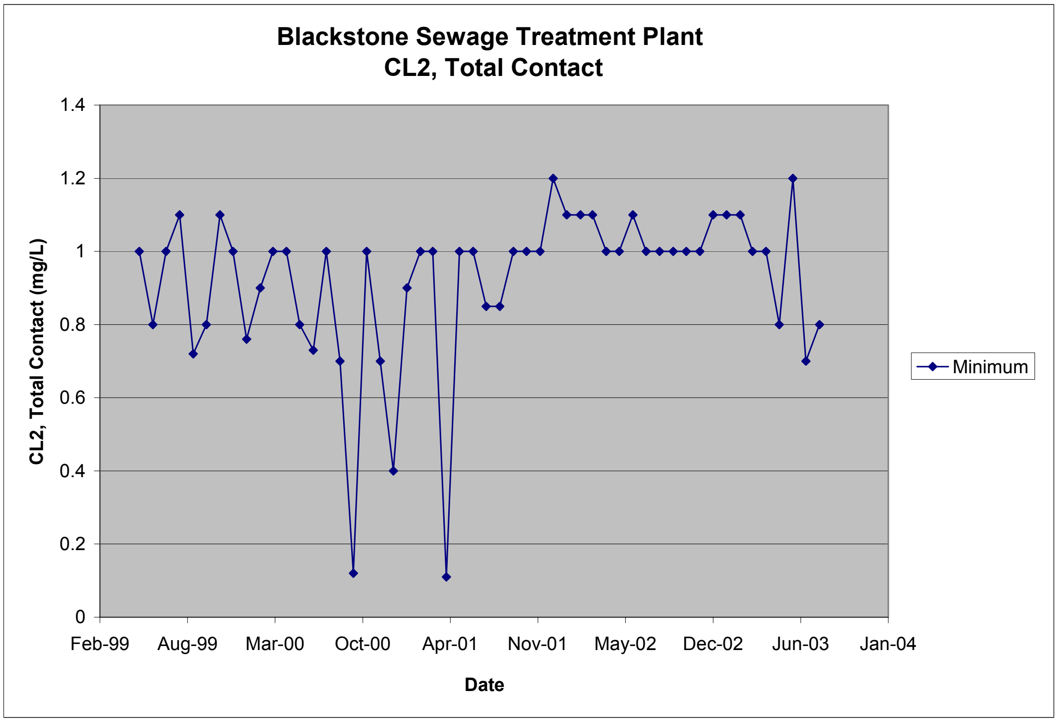


Figure 3-9: Blackstone STP – Dissolved Oxygen

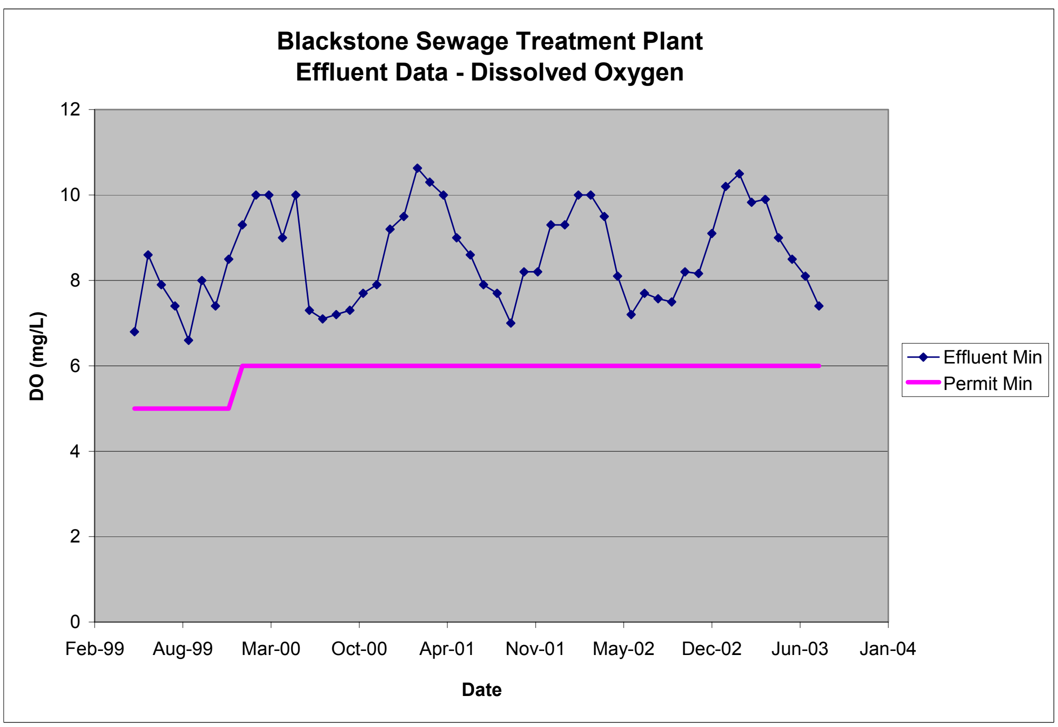


Figure 3-10: Blackstone STP – Hardness as CaCO3

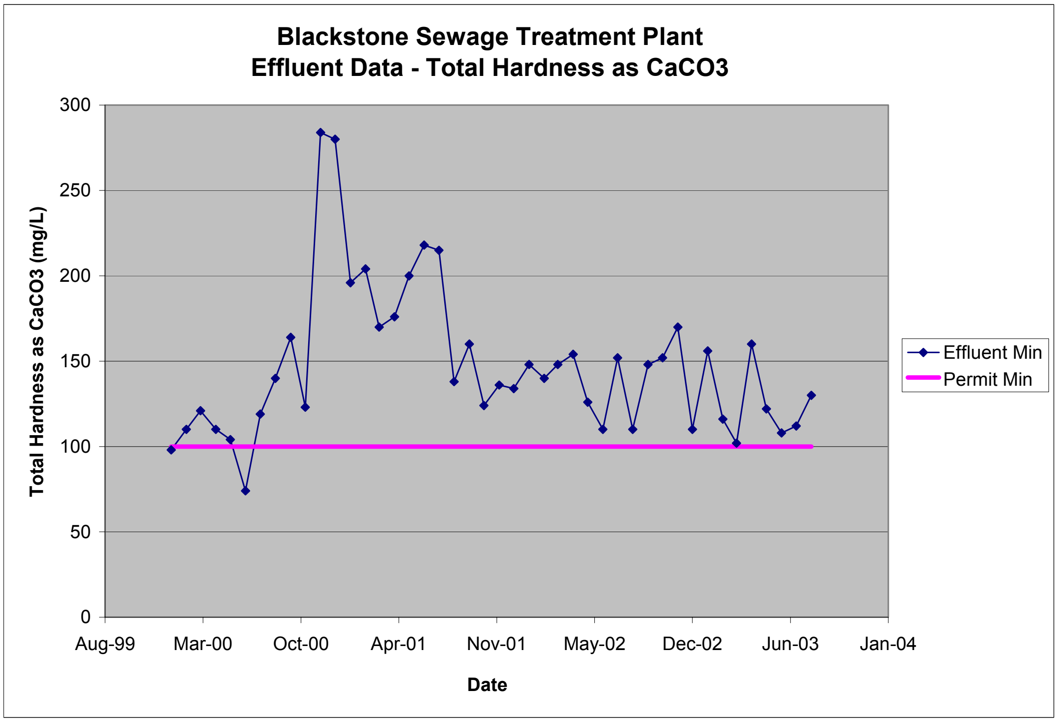


Figure 3-11: Blackstone STP – pH

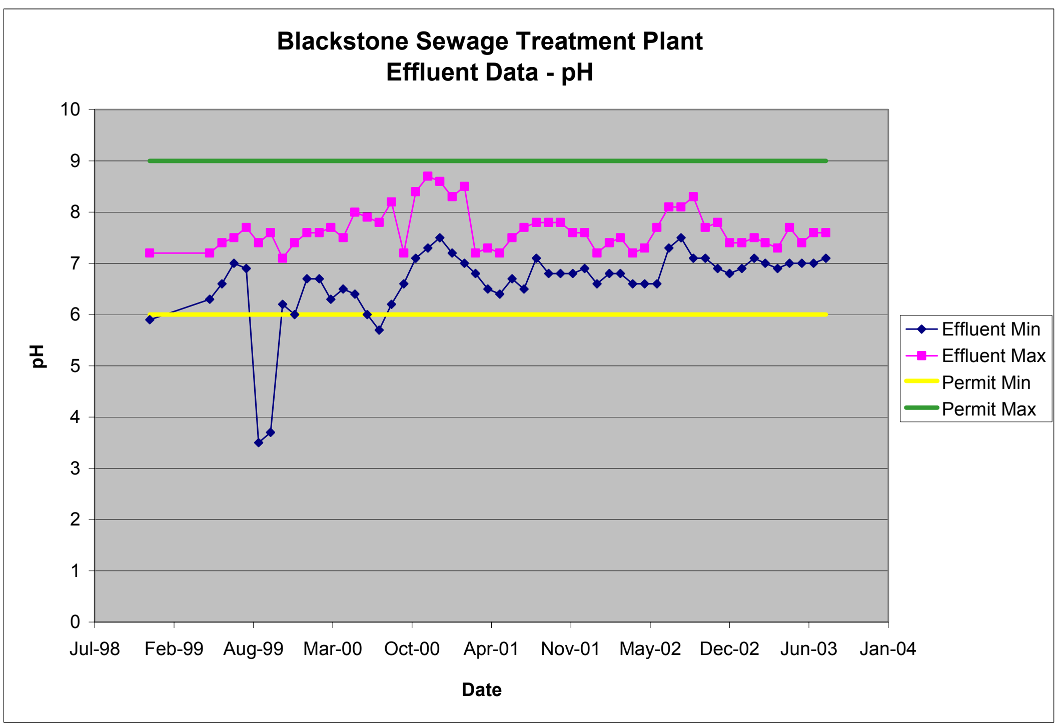


Figure 3-12: Blackstone STP – Total Kjeldahl Nitrogen

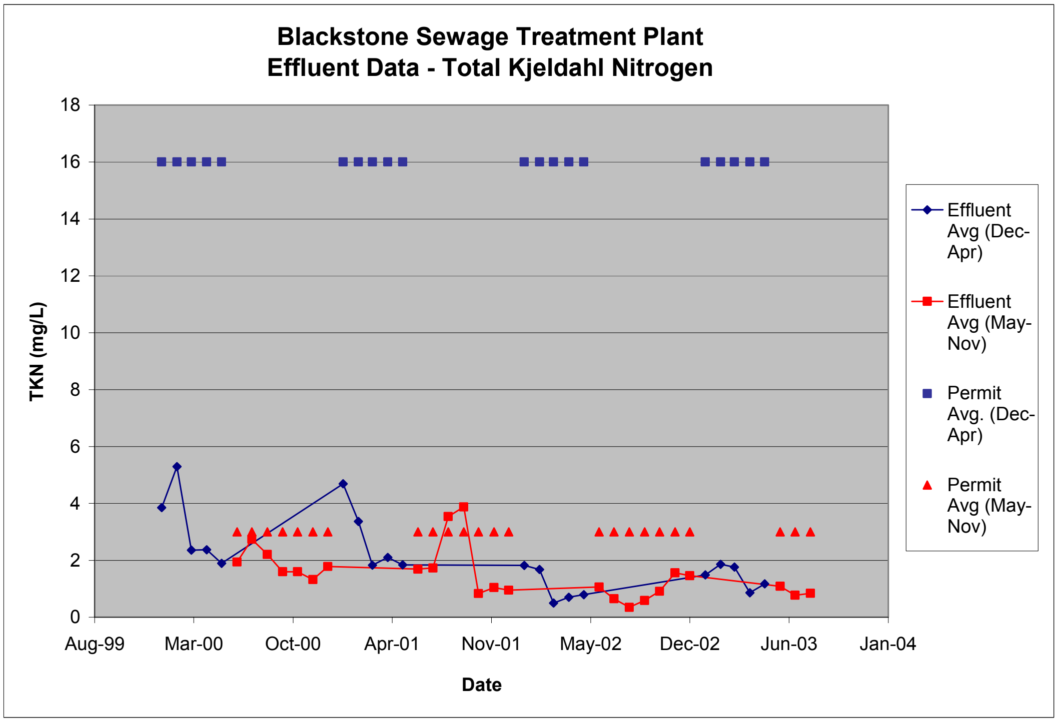


Figure 3-13: Blackstone STP – Total Suspended Solids

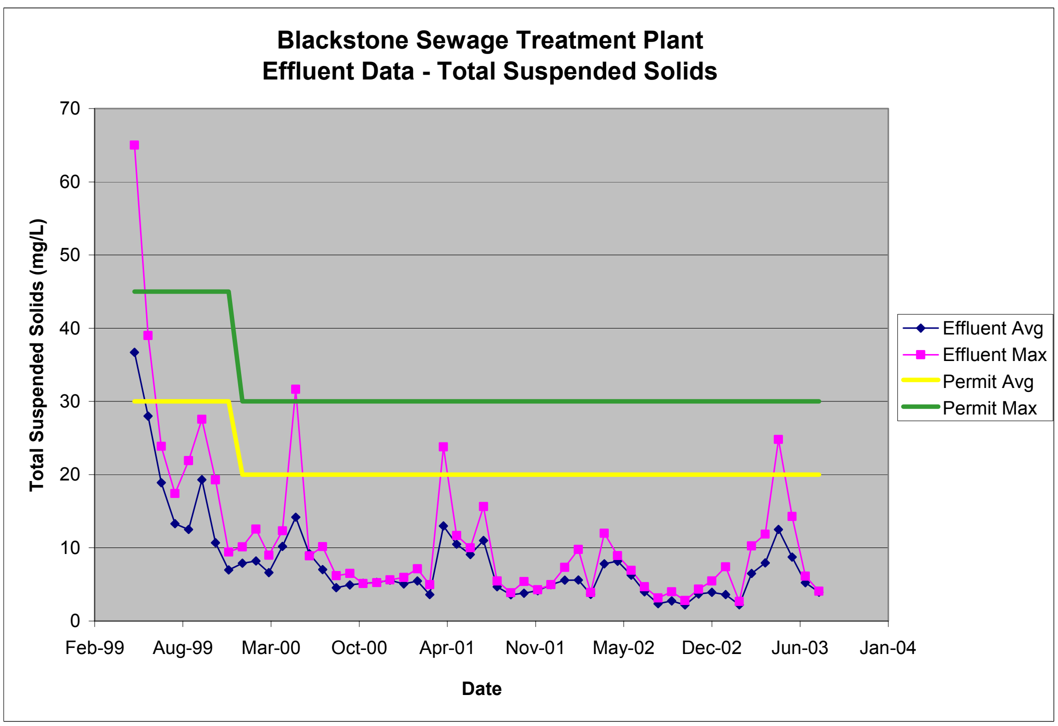


Figure 3-14: Blackstone WTP – pH

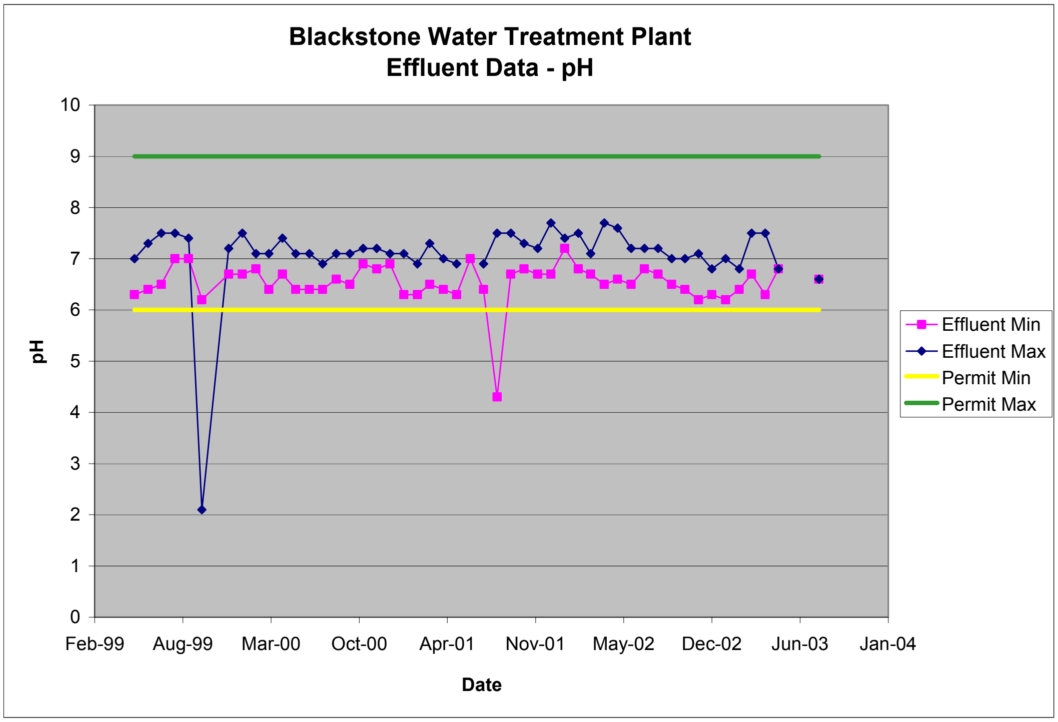
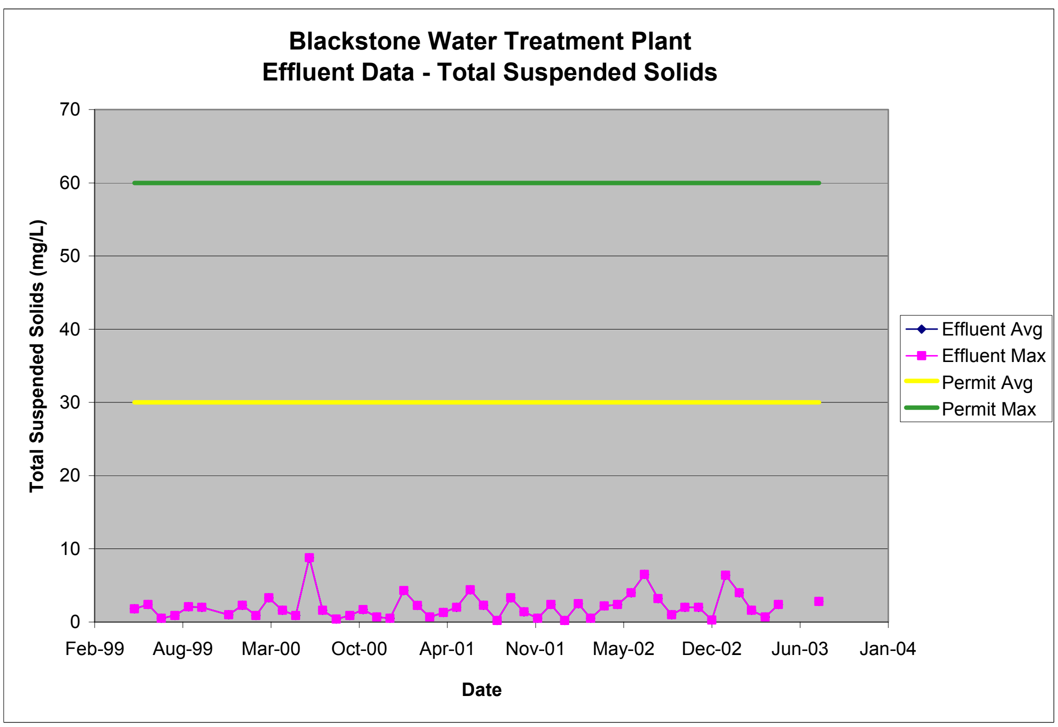


Figure 3-15: Blackstone WTP – Total Suspended Solids



4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) that are impacting the benthic macroinvertebrate community. Stressor identification for Hurricane Branch (UT) was performed using the available environmental monitoring and watershed characterization data discussed in previous sections.

The primary stressor to Hurricane Branch (UT) was determined based on evaluations of candidate stressors that can potentially impact the creek. The 2002 303(d) Impaired Waters Fact Sheet indicated that "erosion and sedimentation problems and the Town of Blackstone Municipal STP discharge" were possible sources of the impairment to the creek. Therefore, sedimentation and hydrologic alteration were considered and evaluated as candidate stressors along with other typical stressors including organic matter, temperature, pH, and toxics. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed.

4.1 Organics

Excessive inputs of organic matter can lead to oxygen depletion, which adversely affects the survival and growth of benthic macroinvertebrates. Common sources of organic matter loading include wastewater discharges and agricultural runoff.

DMR data indicated that the Blackstone STP has been in compliance for carbonaceous biochemical oxygen demand (CBOD) since the plant was upgraded in 2000 (Figures 3-7). An average CBOD concentration of 3.5 mg/L has been observed in the STP effluent, which is well below the permitted seasonal limits of 12.5 and 16.7 mg/L. Prior to the treatment plant upgrade, two violations for biochemical oxygen demand were observed in December of 1998 and January of 1999 (Table 3-7).

Monitored dissolved oxygen levels in the stream have been adequate to support healthy benthic invertebrate populations (Figure 3-2). No violations of the numeric criteria established for Virginia Class III waters have been observed. For these reasons, excessive organic matter loading does not appear to be impairing the benthic community of Hurricane Branch (UT).

4.2 Temperature and pH

Benthic macroinvertebrates require specific temperature and pH ranges in order to survive. Shifts in these parameters, potentially due to factors such as wastewater discharge or urban runoff, may adversely affect the health and composition of the benthic community.

Biomonitoring field data indicated adequate and similar levels of levels of temperature and pH at the impaired and reference stations. No violations of water quality criteria for temperature or pH have been observed (Figures 3-1 and 3-4). Prior to treatment plant upgrades, the Blackstone STP effluent violated the permitted limit for minimum pH on four occasions (Table 3-7). However, since the upgrade, no violations have been observed (Figure 3-11). Based on this evidence, neither temperature nor pH levels appear to be impairing the benthic community in Hurricane Branch (UT).

4.3 Ammonia and Toxics

Prior to the Blackstone STP upgrade in 2000, elevated concentrations of ammonia were observed in the treatment plant effluent (Figure 3-5) which may have contributed to the benthic impairment of Hurricane Branch (UT). However, since the plant upgrade, DMR data indicate that the plant has been in compliance for ammonia discharge with the exception of one violation in January 2001 (Table 3-7). During this same time period, the plant has not violated permit limits for whole effluent toxicity and stream samples collected by DEQ in April 2003 did not indicate toxicity to test organisms. Therefore, although ammonia may have contributed to benthic impairment prior to 2000, elevated ammonia concentrations do not currently appear to be impacting the creek. Likewise, no other toxins appear to be impacting the benthic community of Hurricane Branch (UT) based on the toxicity testing results.

4.4 Sedimentation

In the early 1990's, the DEQ biologist attributed some solids deposition in the creek to the Blackstone STP. However, based on the DMR data presented in Figure 3-13, effluent solids currently do not appear to be a significant source of sediment. Upgrades to the STP have effectively reduced the loading of solids to the creek and no effluent violations have been observed since 2000 (Table 3-7). DMR data also indicated that the solids loading from the Blackstone WTP have been minimal (Figure 3-15). Recently, the WTP began treating its discharge by routing it to the STP and has ceased discharging effluent into the creek except for emergencies.

Habitat assessment scores for sedimentation were identical at both the upstream and downstream biomonitoring stations implying that the treatment plant effluent is not a significant source of solids loading to the creek. However, sedimentation scores for these stations were marginal, suggesting other sources of sediment are present in the watershed. Low sedimentation scores indicate impacts to the benthic macroinvertebrate community through loss of habitat.

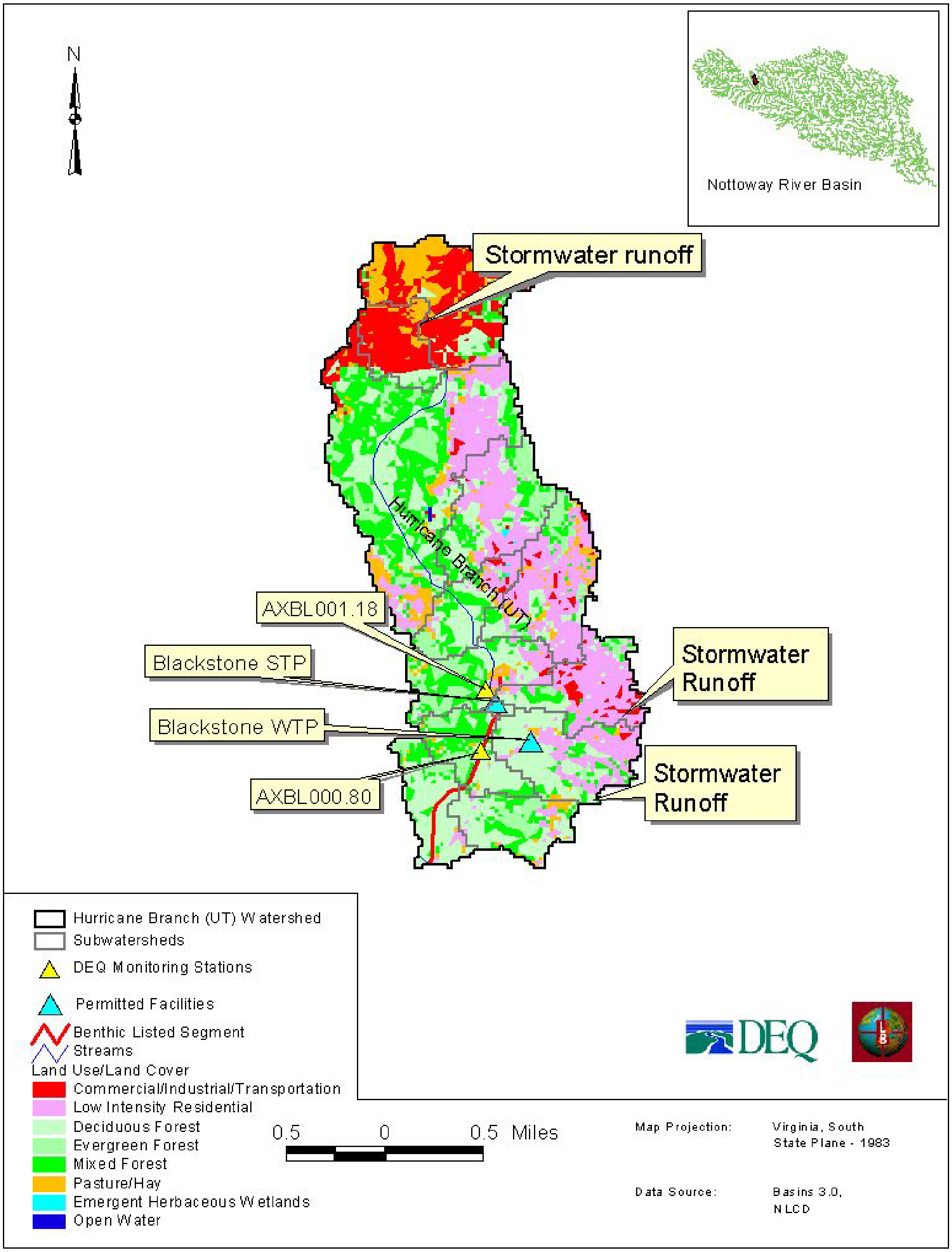
4.5 Hydrologic Alteration

A field visit to the creek was conducted on October 21, 2003. Eroded stream banks and heavy sand deposits were observed along the length of the creek, both in the headwaters as well as downstream of the Blackstone STP. In addition, a flowing tributary located immediately downstream of the treatment plant outfall was noted. Overall, it was evident from field observations that non-point source runoff is adversely impacting the creek.

Developed lands in the watershed represent a significant portion (34%) of the total area. Impervious surfaces associated with developed areas lead to increased stormwater runoff that, in turn, results in higher stream flows. In the Hurricane Branch (UT), stormwater flows delivered to the creek increase as the drainage area increases. Developed lands in the headwaters initially contribute to elevated stream flows impacting the upstream portion of the creek. Further downstream a flowing tributary, as mentioned above, enters the creek in between the two biomonitoring stations. Delineation of subwatersheds for the Hurricane Branch (UT) revealed that 73% of the land drained by this observed tributary is developed. Figure 4-1 provides a map of these delineated subwatersheds. Stormwater flow delivered by this tributary further increases Hurricane Branch (UT) stream flows. Therefore, the downstream portion of the creek is impacted by the cumulative sum of stormwater flows in the drainage area.

This altered hydrology causes stream erosion and sedimentation problems that degrade benthic macroinvertebrate habitat. In addition, elevated stream flows are capable of scouring and flushing out benthic macroinvertebrate populations, as well the habitat in which they live. In particular, productive invertebrate habitats such as leaf packs may be subjected to increased flushing. It should be noted that the DEQ biologist typically sampled leaf packs due to the predominance of sand substrate in the stream. In general, very sparse populations of benthic macroinvertebrates were found.

Figure 4-1: Subwatershed Delineation Indicating Stormwater Runoff Entering Between Monitoring Stations



4.6 Stressor Identification Summary

Based on the evidence and data discussed in the preceding section, hydrologic alteration resulting from non-point source runoff was identified as the primary stressor impacting Hurricane Branch (UT) at this time. Developed lands throughout the watershed represent the primary source of non-point source runoff.

As previously noted, the 303(d) Impaired Waters Fact Sheet indicated that the benthic impairment in Hurricane Branch (UT) was due to "erosion and sedimentation problems and the Town of Blackstone Municipal STP discharge". The STP has been upgraded since the initial 303(d) listing of the creek, however, and this upgrade has resulted in an improved discharge effluent. Ammonia and solids loading from the STP have been significantly reduced and data indicate that the STP has been in substantial compliance for these and other monitored parameters since 2000 (Figures 3-5 to 3-13). Therefore, discharge from the Blackstone STP no longer appears to be adversely impacting the benthic community of the creek.

Hurricane Branch (UT), however, continues to be impacted by non-point source runoff, which is causing erosion, sedimentation, and degradation of the creek. This assessment is based on recent field observations, biological assessments, and land use data for the watershed. Elevated levels of stormwater runoff are resulting from impervious surfaces associated with developed lands within the watershed. Increased stormwater runoff results in higher stream flows that erode the stream channel and flush benthic macroinvertebrate habitat such as leaf packs.

Restoration of the benthic community in Hurricane Branch (UT) is largely dependent upon the management of uncontrolled stormwater runoff associated with developed lands throughout the watershed. Management of non-point source runoff should alleviate the erosion and sedimentation problems currently impacting the creek. It should be noted that the Fort Pickett military base is in the process of developing a new facility master plan which includes provisions for stormwater control. The implementation of such a comprehensive stormwater management plan would have direct and positive impacts on the Hurricane Branch (UT) watershed.

Sediment was selected as a surrogate parameter to represent the instream erosion and sedimentation problems caused by hydrologic alteration. Therefore, a sediment TMDL was developed for Hurricane Branch (UT).

5.0 TMDL Endpoint Identification

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, a reference watershed approach may be used to define the TMDL endpoint.

Hurricane Branch (UT) was initially included on the Virginia 303(d) list for violations of the General Standard (benthic impairment). As detailed in the prior section, hydrologic alteration due to non-point source runoff was identified as the primary stressor causing the benthic impairment in the creek. Since the impacts of hydrologic alteration are manifested as stream erosion and sedimentation problems, a sediment TMDL was developed for Hurricane Branch (UT). Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for Hurricane Branch (UT).

5.1 Reference Watershed Approach

Under the reference watershed approach, the TMDL endpoint for an impaired watershed is established based on conditions in a similar, but non-impaired reference watershed. In the case of sediment, the TMDL endpoint is the sediment loading rate in the non-impaired reference watershed. Reduction of the sediment loading rate in the impaired watershed to levels comparable to the reference watershed is assumed to be sufficient for recovery of the benthic community in the impaired watershed.

Selection of an appropriate reference watershed is based on similarities in watershed characteristics such as soils, topography, land uses, and ecology. Similar watersheds help to ensure similarities in the benthic communities that potentially may inhabit the streams.

Similar watersheds also provide for similar watershed hydrology which influences pollutant loading rates to the stream.

5.2 Selected Reference Watershed

Twittys Creek, located in Charlotte County, Virginia, was selected as the reference watershed for the Hurricane Branch (UT) TMDL development due largely to its proximity to Hurricane Branch (UT) and biomonitoring results for the DEQ reference station on Twittys Creek. Table 5-1 summarizes important criteria considered in the selection of the reference watershed. Comparisons of key watershed characteristics are provided in the following sections.

Table 5-1: Criteria Used in Reference Watershed Selection

Criteria	Relevance
Biomonitoring Data	Biomonitoring data is required to confirm the non-impairment status of the reference watershed and allows for comparisons with the impaired watershed.
Location	Close proximity to the impaired watershed generally improves overall watershed similarity. In addition, the reference watershed should be near a weather station that may be used to characterize precipitation at both watersheds in order to standardize model simulations.
Ecoregion	The reference and impaired watersheds should belong to the same ecoregion to help ensure similarities in stream ecology.
Land Uses	The selected reference watersheds should reflect similar land use distributions. The water quality of streams in a watershed is greatly influenced by land use. Similar land use distributions help to establish achievable TMDL endpoints.
Soils	Soil composition influences watershed runoff, erosion, and stream ecology.
Topography	Topography influences hydrology and is a major component of stream habitat that affects the structure and composition of benthic communities.
Watershed Size	The reference watershed should be similar in size to the impaired watershed since watershed area influences pollutant loading rates to the stream.

5.2.1 Biomonitoring Data

Virginia SCI scores were calculated for the Twittys Creek reference station and compared with Hurricane Branch (UT) biomonitoring stations (Table 5-2). On a regional basis, the Twittys Creek reference station is non-impaired and supports the aquatic life use of the creek.

Table 5-2: Comparison of Virginia SCI Scores

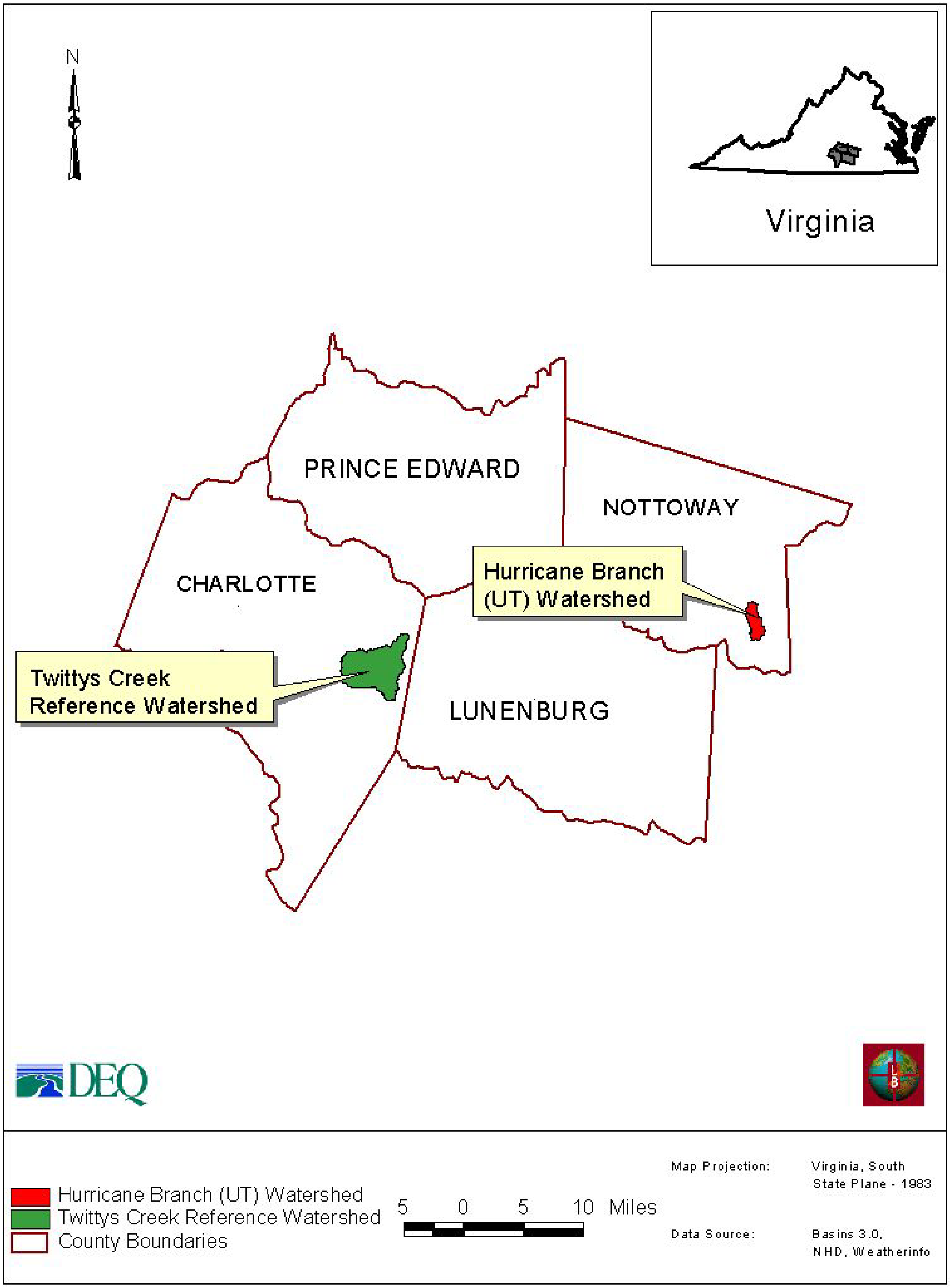
Assessment Date	SCI Score		
	UT Hurricane Recovery Station AXBL000.80	**UT Hurricane Reference Station AXL001.18**	**Twittys Creek Reference Station***
Fall 1994	25	51	68
Spring 1995	14	43	58
Spring 1996	30	55	66
Fall 1996	28	34	63
Spring 1997	24	47	65
Fall 1997	39	60	70
Spring 1998	41	57	-
Spring 2002	30	52	49
Fall 2002	30	51	49
Average	**30**	**50**	**61**

* Station ATWT008.59 has served as the Twittys Creek reference since 2002.
Station ATWT007.24 was used previously.

5.2.2 Watershed Location

The Twittys Creek reference watershed, delineated at river mile 8.59, is located about 30 miles west of the Hurricane Branch (UT) watershed (Figure 5-1). Both watersheds are located in the Piedmont ecoregion.

Figure 5-1: Location of the Hurricane Branch (UT) Watershed and the Twittys Creek Watershed



5.2.3 Land Use

A comparison of land use distributions in the Hurricane Branch (UT) and Twittys Creek watersheds is provided in Table 5-3. The Twittys Creek reference watershed is dominated by forested lands (82.6%). The Hurricane Branch (UT) watershed is also primarily forested (57.5%), but has a significant percentage of developed lands (34%) which alters the hydrology of the watershed. As discussed in Section 4.0, developed lands represent the primary source of stormwater runoff that is impacting Hurricane Branch (UT). Although the Twittys Creek reference watershed has significantly less developed lands than the Hurricane Branch (UT) watershed, no other non-impaired reference watershed with a higher percentage of developed lands was available in the region.

Table 5-3: Summary of Land Use Distributions for Hurricane Branch (UT) and Twittys Creek

Land Use Category	% of Total Watershed	
	Hurricane Branch (UT)	Twittys Creek
Forest	57.5	82.6
Agricultural	8.2	8.5
Developed	34.2	1.0
Water/Wetlands	0.1	6.2
Barren	0.0	1.8
Total	**100**	**100**

5.2.4 Soils Distribution

A comparison of soil distributions for the Twittys Creek and Hurricane Branch (UT) watersheds is provided in Table 5-4. The soil series in both the Twittys Creek and Hurricane Branch (UT) watersheds consist of well-drained soils, and are predominantly classified as hydrologic soil group “B”. Therefore, soils in the Twittys Creek reference watershed are representative of soils in the Hurricane Branch (UT) watershed.

Table 5-4: Summary of Soil Distributions for Hurricane Branch (UT) and Twittys Creek

Soil Id	Soil Name	Hydrologic Group	% of Total Watershed	
			Hurricane Branch (UT)	Twittys Creek
VA019	Cecil-Madison-Enon	B,C,D	0.0	7.6
VA030	Appling-Wedowee-Louisburg	B	100	0.0
VA032	Chewacla-Wehadkee-Congaree	B	0.0	0.9
VA045	Georgeville-Nason-Lignum	B	0.0	91.5

6.0 Sediment Loading Determination

A reference watershed approach was used to develop the sediment TMDL for the Hurricane Branch (UT) watershed as discussed in the previous section. Twittys Creek, located in Charlotte County, Virginia served as the reference watershed (Figure 5-1). The sediment loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Hurricane Branch (UT).

6.1 Sediment Source Assessment

Excessive sedimentation can adversely affect benthic invertebrate communities through the loss of habitat or food sources. Sediment can be delivered to the stream from point sources located in the watershed and it can be carried in the form of non-point source runoff from non-vegetated or protected land areas. In addition, sediment can be generated in the stream through the processes of scour and deposition which are primarily a function of stream flow. During periods of high flow, erosion of the stream channel occurs. The eroded materials are deposited downstream as stream flow decreases. These processes adversely impact the benthic macroinvertebrate community through loss of habitat and degradation of water quality.

Potential sediment sources within the Hurricane Branch (UT) watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Non-Point Sources

The erosion of land is dependent upon many factors including land use type and cover, soils type, and topography. The land use types in the Hurricane Branch (UT) watershed were characterized using NLCD data, while soil types were characterized using the STATSGO database. The land use distribution for the Hurricane Branch (UT) watershed was previously shown in Table 2-3 and a summary of soil types was provided in Table 2-1. The delivery of eroded soils to the stream is primarily influenced by watershed size.

Sediment loadings from generalized land use types present in the Hurricane Branch (UT) watershed are discussed below.

Forested Lands

Sediment loads from forested lands are typically low due to extensive root systems and vegetative cover that serve to stabilize soils. In addition, forest canopies intercept and dampen rainfall impacts.

Agricultural lands

Sediment loads from agricultural lands tend to be elevated due to the exposure of soil that occurs in agricultural practices. Cropland and pastureland are two sources of elevated sediment loads.

Developed Lands

Developed lands consist of both pervious and impervious surfaces. Impervious surfaces are not subject to soil erosion, but sediment loads may result from the washoff of solids deposited on impervious surfaces. Sediment loads from developed lands tend to be high. In addition, elevated levels of uncontrolled stormwater runoff from developed lands contribute to streambank erosion as discussed below.

Water/Wetlands

The amount of sediment loading from water and wetland areas typically is not significant.

6.1.2 Point Sources

Sediment loadings from point sources are attributable to the suspended solids present in discharge effluent. The Blackstone STP discharges solids to Hurricane Branch (UT). As stated previously, the Blackstone WTP recently began routing its effluent to the STP for treatment, and does not currently directly discharge effluent into Hurricane Branch (UT).

6.1.3 Instream Bank Erosion

Sediment derived from instream bank erosion is also dependent upon numerous watershed characteristics. Land use types present in the watershed may affect hydrology of the watershed. In particular, highly developed lands may lead to increased stream flows that erode the stream channel and banks. Likewise, watersheds defined by steep topography may experience high levels of runoff that cause instream erosion. The level of instream erosion is dependent on the erodibility of the soil, normally defined as the soil K factor.

6.2 Technical Approach for Estimating Sediment Loads

6.2.1 Non-point Source Load

For the purpose of TMDL development, annual sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model.

6.2.1.1 GWLF Model Description

GWLF is a time variable simulation model that simulates hydrology and sediment loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Erosion and sediment loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a sediment delivery ratio is applied to determine the sediment loadings to the stream. Sediment loadings from each source area are summed to obtain a watershed total.

6.2.2 Point Source Load

Two point source facilities are present in the Hurricane Branch (UT) watershed as shown in Table 6-1. No point sources are present in the reference watershed. For the purpose of

TMDL development, annual point source loadings were computed based on the permitted discharge loading rate for total suspended solids.

Table 6-1: Point Sources in Hurricane Branch (UT) Watershed

Facility Name	Permit No.	Permitted Total Suspended Solids (kg/day)	Annual Sediment Loading (tons/year)
Blackstone STP	VA0025194	151.4	60.9
Blackstone WTP	VA0005827	NA*	NA*
*The Blackstone WTP now routes its discharge to the Blackstone STP.			

6.2.3 Instream Erosion

Instream erosion for the Hurricane Branch (UT) impaired watershed and the Twittys Creek reference watershed was calculated using a spatial technique developed by Evans et al. (2003) that estimates streambank erosion based on watershed characteristics. Using this method, a watershed-specific lateral erosion rate is calculated as follows:

$$LER = aQ^{0.6}$$

Where:
LER = an estimated lateral erosion rate, expressed as meters per month
a = an empirically-derived "erosion potential factor"
Q = monthly stream flow, expressed as cubic meters per second.

The 'a' factor is computed based on a wide variety of watershed parameters including the fraction of developed area of the watershed, average field slope, mean soil erodibility (K factor), average curve number value, and the mean livestock density for the watershed.

$$a = (0.00147*PD) + (0.000143*AD) - (0.000001*CN) + (0.000425*KF) + (0.000001*MS) - 0.000016$$

Where:
PD = fraction developed land
AD = animal density measured in animal equivalent units/acre
CN = area-weighted runoff curve number value
KF = area-weighted K factor
MS = mean field slope

The fraction of developed land in the impaired and reference watersheds was obtained from NLCD data. The mean soil erodibility K factor and mean field slope of the watersheds were computed from the STATSGO database. The average watershed curve number was developed based on curve numbers applied in the GWLF model. Livestock densities for the watersheds were based on the Nottoway and Charlotte County livestock inventories. The 'a' factors for the Hurricane Branch (UT) impaired and reference watersheds were computed.

LER values were calculated using predicted stream flow from the GWLF model. Monthly sediment loads from streambank erosion (kg/month) were then calculated as the product of the LER (meters/month), total stream length (meters), average streambank height (meters), and average soil bulk density (kg/m^3). The total stream length for Hurricane Branch (UT) and Twittys Creek was obtained from the National Hydrography Dataset (NHD). Bank height was estimated from field surveys of the two watersheds. Mean soil bulk density was obtained from the STATSGO database. Annual sediment loads from streambank erosion were computed as the summation of monthly loads.

6.3 GWLF Model Setup and Calibration

6.3.1 GWLF Model Development

GWLF model simulations were performed for 1990 to 2002 in order to reflect the period of biomonitoring assessments that resulted in the impairment listing of Hurricane Branch (UT). In addition, the 12 year simulation period accounts for both seasonal and annual variations in hydrology and sediment loading. Models were developed for both the reference and impaired watersheds. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF that facilitates the creation of model input files and processing of model results.

6.3.2 Weather Data

Daily precipitation and temperature data for the Camp Pickett weather station (Coop ID 440166) were obtained from the National Climatic Data Center and used for model simulations. The Camp Pickett station, located in Nottoway County, is the closest weather station in the area for the specified modeling period. Table 6-2 provides a summary of the weather data used in the model.

Table 6-2: Annual Precipitation and Temperature for Camp Pickett Weather Station

Water Year (Apr-Mar)	Total Precipitation (cm)	Average Temperature (Deg. C)
1990-1991	116	14.6
1991-1992	93	14.8
1992-1993	129	13.4
1993-1994	109	13.7
1994-1995	100	13.9
1995-1996	118	12.8
1996-1997	146	13.6
1997-1998	126	13.2
1998-1999	98	14.4
1999-2000	124	13.9
2000-2001	121	12.9
2001-2002	92	14.2
Average	114	13.8
Maximum	92	12.8
Minimum	146	14.8

6.3.3 Model Input Parameters

In addition to weather data, GWLF requires specification of input parameters relating to hydrology, erosion, and sediment yield. In general, Appendix B of the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters.

Runoff curve numbers and USLE erosion factors are specified as an average value for a given source area. The NLCD land use types present in the impaired and reference watersheds (Table 6-3) were used to define model source areas. Therefore, a total of 8 source areas were defined in the model in the impaired watershed, while 11 source areas were defined for the impaired watershed. As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Table 6-3: Land Use Distributions Used in GWLF Model

General Land Use Category	NLCD Land Use Type	Percentage of Watershed	
		Hurricane Branch (UT) Impaired Watershed	Twittys Creek Reference Watershed
Forested	Deciduous Forest	26.7	39.5
	Evergreen Forest	10.3	28.6
	Mixed Forest	20.5	16.6
Agricultural	Pasture/Hay	8.2	6.4
	Row Crops	NA	0.5
Developed	Low Intensity Residential	23.1	0.5
	Commercial/Industrial	11.1	0.1
Water/Wetlands	Open Water	0.0	0.8
	Woody Wetlands	NA	5.3
	Emergent Herbaceous	0.1	0.3
Barren	Transitional	NA	1.3
Total		**100.0**	**100.0**
NA: Land use not present in watershed.			

Runoff curve numbers were developed for each model source area in the watershed based on values published in the NRCS Technical Release 55 (NRCS, 1986). STATSGO soils GIS coverages were analyzed to determine the dominant soil hydrologic groups for each model source area. Evapotranspiration cover coefficients were developed based on values provided in the GWLF manual (Haith et al., 1992) for each model source area. Average watershed monthly evapotranspiration cover coefficients were computed based on an area weighted method. Initialization and groundwater hydrology parameters were set to default values recommended in the GWLF manual.

USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple sources based on data availability. County specific values for KLSCP factors, contained in the NRCS National Resources Inventory (NRI) database, were used when available for model source areas. Otherwise, average KLSCP values for model source areas were determined based on GIS analysis of soils and topographic coverages, and literature review. The rainfall erosivity coefficient was determined from values given in the GWLF manual. The sediment delivery ratio was computed directly in BasinSim.

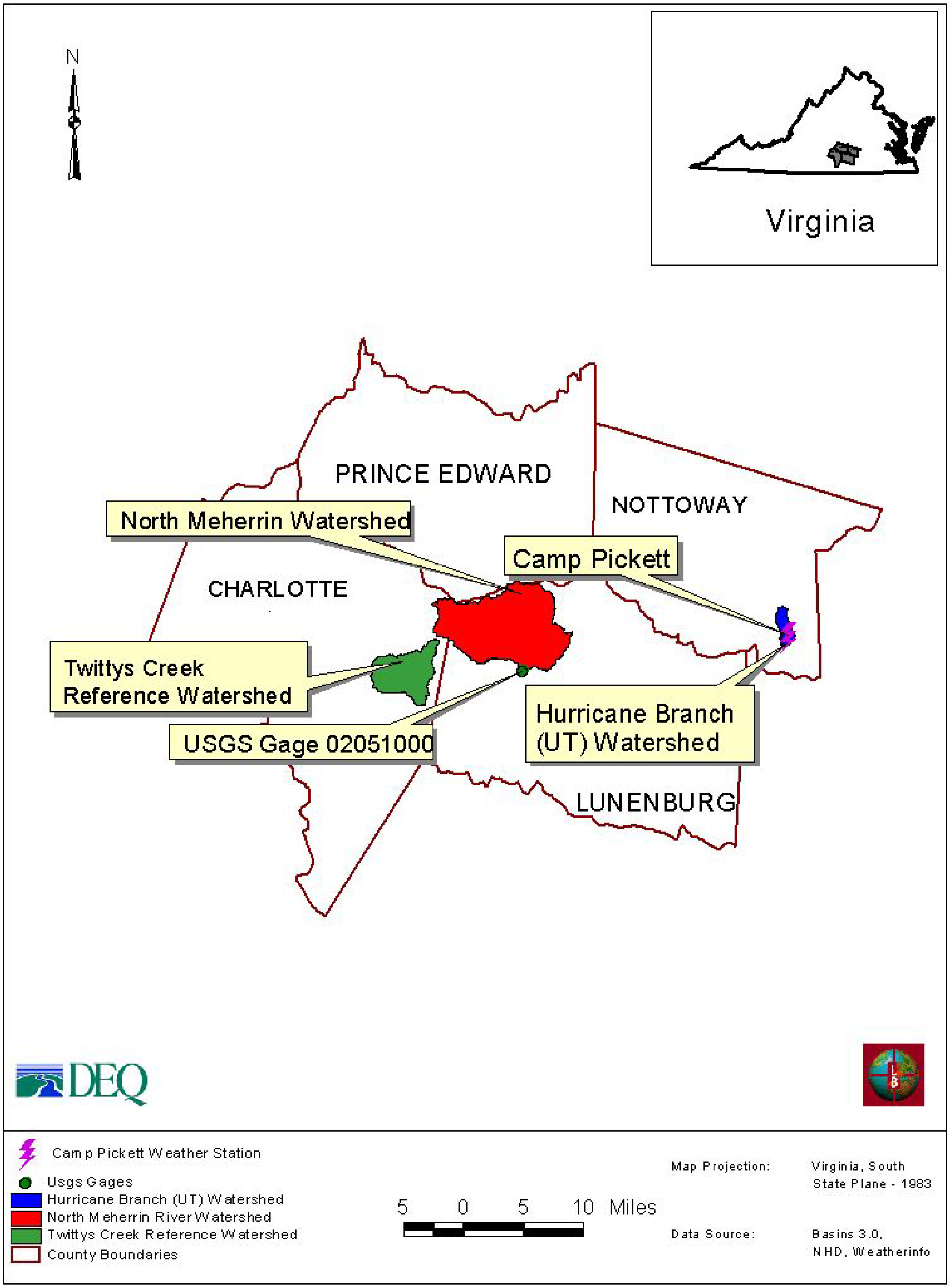
Developed lands include impervious surfaces that are not subject to soil erosion. Rather, sediment loads from developed lands result from the buildup and washoff of solids deposited on the surface. Therefore, sediment loads from developed lands were not modeled using the USLE. Instead, sediment loads from developed lands were computed based on typical loading rates from developed lands (Horner et al., 1994).

6.3.4 Hydrology Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to be implemented without calibration. Nonetheless, comparisons were made between predicted and observed stream flow to ensure the general validity of the model.

Since daily streamflow data are not available for Hurricane Branch (UT) or Twittys Creek, flow gages in the region were examined for calibration purposes. The USGS gage on the North Meherrin River near Lunenburg, VA (Station 02051000) was selected for hydrology calibration for the reference watershed based on the period of available monitoring data, similarities in watershed land uses, and proximity to the reference watersheds and weather station. Figure 6-1 provides the location of the flow gage and weather station in relation to the reference watershed. GWLF parameters relating to hydrology were calibrated based on the North Meherrin River flow data for the reference watershed.

Figure 6-1: Location of USGS Flow Gage and Weather Station



Since the North Meherrin River watershed is primarily forested like the Twittys Creek watershed, the two watersheds share a similar hydrology. However, the Hurricane Branch (UT) watershed has a significant percentage of developed lands, which results in increased stormwater runoff. Therefore, the stream flow of the Hurricane Branch (UT) watershed is expected to be higher than that exhibited in Twittys Creek. For this reason, hydrology parameters in the GWLF model for Hurricane Branch (UT) were adjusted to reflect the land use distribution of the watershed. No representative USGS flow gage in the region was available for calibration, however, modeled stream flow for Hurricane Branch (UT) was compared with modeled stream flow for Twittys Creek to evaluate differences between the two watersheds.

The hydrology calibration for the Twittys Creek reference watershed is shown in Figure 6-2. Table 6-4 provides stream flow calibration statistics. A total flow volume error of about six percent was achieved for reference watershed. In general, model predictions reflect the flow variations observed at the USGS gage station as evidenced by the R^2 value of 0.72. A comparison of modeled stream flow for Hurricane Branch(UT) and Twittys Creek is shown in Figure 6-3. As expected, the stream flow values for Hurricane Branch (UT) are significantly higher than Twittys Creek, reflecting increases associated with stormwater runoff.

Table 6-4: Hydrology Calibration Statistics for Twittys Creek Reference Watershed (UT)

GWLF Simulation	Simulation Period	R2 Correlation Value	Total Flow % Error
Twittys Creek Reference Watershed	1990 – 2002	0.72	6.4

Figure 6-2: Hydrology Calibration Results for Twittys Creek Reference Watershed

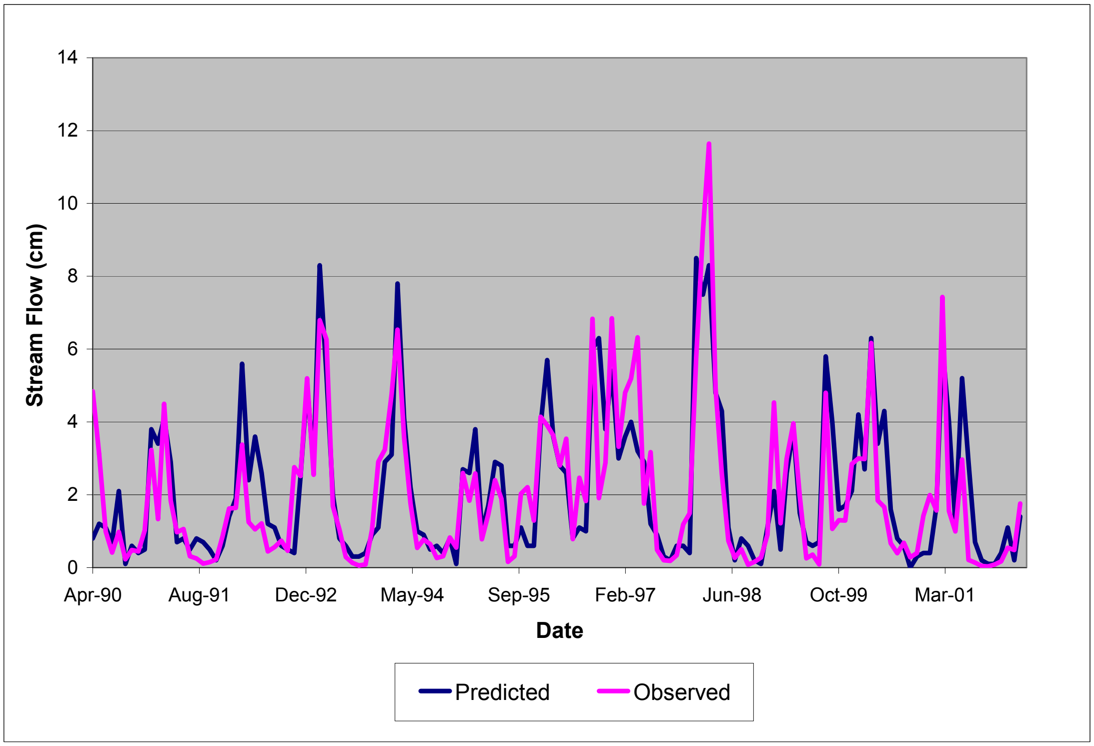
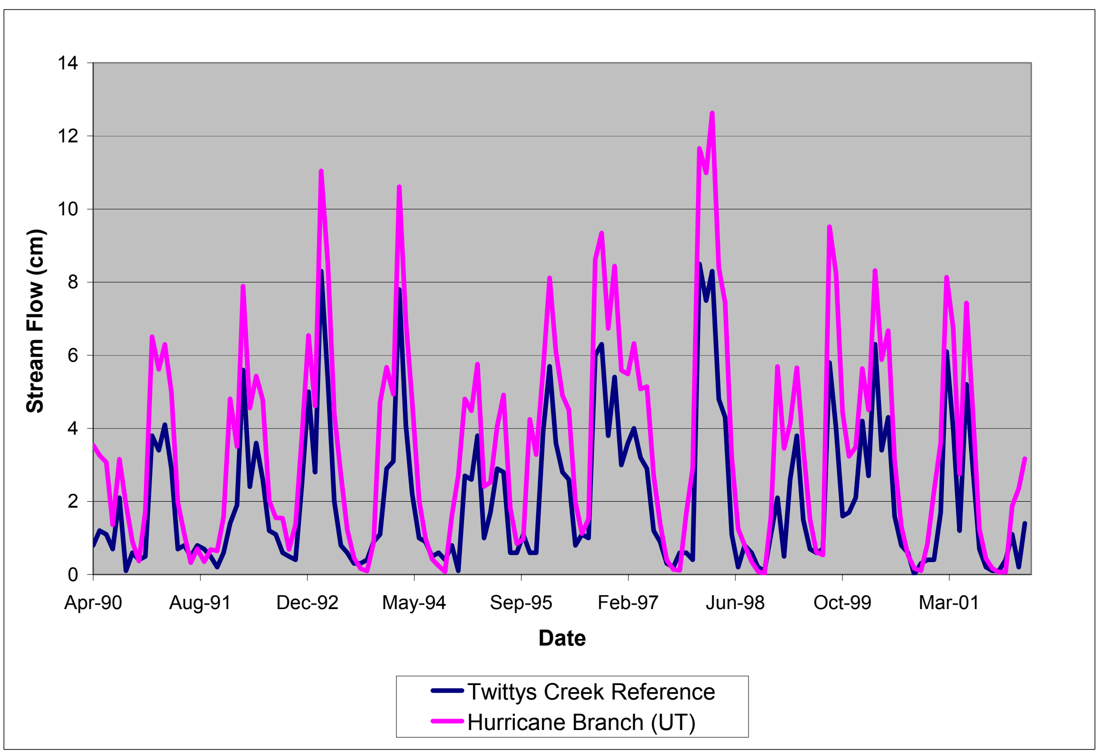


Figure 6-3: Hydrology Comparison Between Hurricane Branch (UT) and Twittys Creek



6.4 Sediment Load Estimates

6.4.1 Sediment Loads from Non-point Sources

The hydrologically calibrated model was used to estimate sediment loadings from each source area in the Hurricane Branch (UT) and Twittys Creek watersheds. Based on the 12 year simulation period from 1990 to 2002, average annual sediment loads were computed for each land source in each watershed. These results are presented Table 6-5.

Table 6-5: Hurricane Branch (UT) and Twittys Creek Average Annual Sediment Loads (tons/yr) from Land Sources

Land Use Type	Hurricane Branch (UT)	Twittys Creek (Reference Watershed)
Deciduous Forest	4.4	37.7
Evergreen Forest	1.7	27.3
Mixed Forest	3.4	15.9
Pasture/Hay	25.7	192.3
Row Crop	NA	75.1
Low Intensity Residential	2.3	0.3
Commercial/Industrial	102.7	6.5
Open Water	0.0	0.0
Woody Wetlands	NA	0.0
Emergent Herbaceous	0.0	0.0
Transitional	NA	186.4
NA: Land use not present in watershed.		

6.4.2 Sediment Loads from Instream Erosion

Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003), as described in Section 6.2.3. The 'a' factor used in the streambank erosion equation was computed using watershed specific data for the impaired and reference watersheds. Computed 'a' factors and annual sediment loads from streambank erosion are presented in Table 6-6.

Table 6-6: Hurricane Branch (UT) and Twittys Creek Annual Instream Erosion Estimates

Watershed	Computed 'a' Factor	Instream Erosion (tons/yr)
Hurricane Branch (UT) Impaired Watershed	$7.17*10^{-4}$	50.7
Twittys Creek Reference Watershed	$7.91*10^{-5}$	48.5

6.5 Existing Sediment Loadings – All Sources

In summary, average annual sediment loads for the Hurricane Branch (UT) and Twittys Creek watersheds were determined as follows:

- Erosion and sediment yield from land sources were modeled using GWLF.
- Instream bank erosion was computed based on the method described by Evans et al. (2003).
- Sediment loads from point sources were calculated based on the permitted total suspended solids loading rate for each facility.

In addition, average annual sediment loads for an area-adjusted reference watershed were computed for the purpose of TMDL development. As stated previously, under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Twittys Creek reference watershed is larger than the Hurricane Branch (UT) watershed, sediment loadings for the reference watershed needed to be adjusted to reflect the size of the Hurricane Branch (UT) watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the Twittys Creek reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed. In addition, instream erosion for the adjusted Twittys Creek reference watershed was calculated using the total stream length of the Hurricane Branch (UT) watershed.

Average annual sediment loads from all sources for the Hurricane Branch (UT), Twittys Creek, and area-adjusted Twittys Creek watersheds are summarized in Table 6-7. The total existing sediment load in the impaired watershed is 252 tons per year. The area-adjusted reference watershed load of 145 tons per year represents the TMDL endpoint. Reduction of sediment loading in the Hurricane Branch (UT) watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Hurricane Branch (UT).

Table 6-7: Hurricane Branch (UT) and Twittys Creek Average Annual Sediment Loadings (tons/yr)

Source	Land Use Type	Hurricane Branch (UT) Watershed	Twittys Creek Reference Watershed	Twittys Creek Adjusted Reference Watershed
Land Sources	Deciduous Forest	4.4	37.7	9.7
	Evergreen Forest	1.7	27.3	7.0
	Mixed Forest	3.4	15.9	4.1
	Pasture/Hay	25.7	192.3	49.5
	Row Crop	NA	75.1	19.4
	Low Intensity Residential	2.3	0.3	0.1
	Commercial/Industrial	102.7	6.5	1.1
	Open Water	0.0	0.0	0.0
	Woody Wetlands	NA	0.0	0.0
	Emergent Herbaceous	0.0	0.0	0.0
	Transitional	NA	186.4	48.0
Instream Erosion	-	50.7	48.5	5.5
Point Sources	-	60.9	0.0	0.0
Total		251.7	590.1	144.5
NA: Land use not present in watershed				

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Hydrologic alteration was identified as the primary stressor to the benthic community in Hurricane Branch (UT). Sediment was selected as a surrogate parameter to represent the instream erosion and sedimentation problems caused by hydrologic alteration as previously discussed in Section 4.0. Therefore, a sediment TMDL was developed using a reference watershed approach. The total average annual sediment loading for the Twittys Creek area-adjusted reference watershed (Table 6-7) represents the TMDL endpoint for the Hurricane Branch (UT) impaired watershed. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Hurricane Branch (UT).

7.1 Basis for TMDL Allocations

Sediment TMDL allocations for Hurricane Branch (UT) were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Sediment Load of the Area-Adjusted Reference Watershed

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for Hurricane Branch (UT) to account for uncertainties in the methodologies used to determine sediment loadings.

7.1.2 Wasteload Allocation

The wasteload allocated to point sources in the watershed was based on the permitted discharge loading rate for total suspended solids for each facility as shown in Table 7-1. Because the sediment load from these facilities typically consists of the non-settleable sediment fraction, no reductions are required for these sources.

Table 7-1: Recommended Wasteload Allocations for Hurricane Branch (UT)

Facility Name	Permit Number	Permitted Load (tons/yr)	Allocated Load (tons/yr)	Percent Reduction
Blackstone STP	VA0025194	60.9	60.9	0
Blackstone WTP	VA0005827	NA*	NA*	0
Total	-	60.9	60.9	0
*The Blackstone WTP now routes its discharge to the Blackstone STP.				

7.1.3 Load Allocation

Load allocations for non-point sources were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural and developed lands and instream erosion by 67%, the sediment TMDL endpoint is achieved. The existing and allocated sediment loads for each non-point source in the Hurricane Branch (UT) watershed are presented in Table 7-2. In addition, the necessary percent reduction is shown for each source.

Table 7-2: Recommended Load Allocations for Hurricane Branch (UT)

Source	Land Use Type	Hurricane Branch (UT) Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	4.4	4.4	0
	Evergreen Forest	1.7	1.7	0
	Mixed Forest	3.4	3.4	0
	Pasture/Hay	25.7	8.4	67
	Low Intensity Residential	2.3	0.8	67
	Commercial/Industrial	102.7	33.8	67
	Open Water	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
Instream Erosion	-	50.7	16.7	67
Total		190.8	69.1	64

7.2 Overall Recommended TMDL Allocations

The total load and wasteload allocations and margin of safety for Hurricane Branch (UT) are summarized in Table 7-3. Recommended allocations for each source in the watershed are provided in Table 7-4. Overall, the sediment load in the Hurricane Branch (UT) watershed must be reduced by 48% to meet the established TMDL endpoint.

Table 7-3: Sediment TMDL for Hurricane Branch (UT) (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
144.5	69.1	60.9	14.5

Table 7-4: Recommended TMDL Allocations for Hurricane Branch (UT)

Source	Land Use Type	Hurricane Branch (UT) Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	4.4	4.4	0
	Evergreen Forest	1.7	1.7	0
	Mixed Forest	3.4	3.4	0
	Pasture/Hay	25.7	8.4	67
	Low Intensity Residential	2.3	0.8	67
	Commercial/Industrial	102.7	33.8	67
	Open Water	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
Instream Erosion	-	50.7	16.7	67
Point Sources	-	60.9	60.9	0
Total		251.7	130.0	48

7.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of Hurricane Branch (UT), hydrologic alteration was identified as the primary stressor and sediment was selected as a surrogate pollutant to represent the impacts from high stormwater flows. High stream flow periods, resulting from elevated stormwater runoff levels, represent the critical condition associated with hydrologic alteration. Elevated stream flows erode the stream channel and flush benthic macroinvertebrate habitat. Approximately 76% of the total average annual sediment load to the Hurricane Branch (UT) is delivered from non-point sources and in-stream erosion during high flow periods associated with stormwater runoff.

Potential point source impacts under low flow conditions are not considered significant. The modeled stream flow for Hurricane Branch (UT) ranged from 0.031 to 13.8 cfs at the mouth of the creek, which scales to 0.022 to 9.7 cfs at the Blackstone STP outfall. The 7Q10 low flow condition used to develop permit limits for the Blackstone STP discharge is 0.0052 MGD (0.008 cfs). Under this low flow condition, the Blackstone STP effluent comprises almost 100% of the stream flow when operating at maximum design flow. However, permit discharge limits are designed to protect aquatic life under the 7Q10 low flow condition. As noted previously, the STP has been in compliance for all permitted discharge limits since 2000, with the exception of one ammonia violation attributed to illegal dumping and two violations of total Kjeldahl nitrogen in 2001. TSS loadings during low flow periods do not have a significant impact on the benthic macroinvertebrate community in Hurricane Branch (UT). Rather, high flows resulting from uncontrolled stormwater runoff are the primary cause of the benthic impairment.

Since sediment loading occurs throughout the year and its impacts on benthic invertebrates are often a function of cumulative loading rather than particular events, it is appropriate to consider sediment loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 12 year simulation period used in the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and sediment loading by using a daily time-step for water balance calculations. Therefore, the 12 year simulation performed with GWLF adequately captures seasonal variations.

8.0 Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairments on Hurricane Branch (UT). The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent “TMDL Implementation Plan Guidance Manual”, published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

8.1 Staged Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;
3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

8.2 Stage 1 Scenarios

A load allocation scenario to reduce sediment loading to Hurricane Branch (UT) was presented in Section 7.0. Under this scenario, the sediment TMDL endpoint is achieved by reducing sediment loads from agricultural and developed lands by 67%, as well as reducing instream erosion by 67%. Allocated sediments loads and the percent reduction required for all watershed sources are presented in Table 8-1.

Table 8-1: Recommended TMDL Allocations for Hurricane Branch (UT)

Source	Land Use Type	Hurricane Branch (UT) Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	4.4	4.4	0
	Evergreen Forest	1.7	1.7	0
	Mixed Forest	3.4	3.4	0
	Pasture/Hay	25.7	8.4	67
	Low Intensity Residential	2.3	0.8	67
	Commercial/Industrial	102.7	33.8	67
	Open Water	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
Instream Erosion	-	50.7	16.7	67
Point Sources	-	60.9	60.9	0
Total		251.7	130.0	48

8.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to ongoing water quality improvement efforts aimed at restoring water quality in the Hurricane Branch (UT) watershed.

Some of the ongoing activities in the watershed that will have a direct and a positive impact on the water quality conditions include Fort Pickett's ongoing comprehensive stormwater management plan and onsite environmental restoration efforts such as reforestation.

8.4 Reasonable Assurance for Implementation

8.4.1 Follow-Up Monitoring

VADEQ will continue monitoring stations AXBL00.80 and AXBL001.18 in accordance with its biological monitoring program. VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

8.4.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Additionally, Virginia's 1997 Water Quality Monitoring Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

8.4.3 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a major source of funds for Virginia's Non-point Source Management Program. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

9.0 Public Participation

The development of the Hurricane Branch (UT) TMDL would not have been possible without public participation. A technical advisory committee (TAC) meeting and two public meetings were held for the Hurricane Branch (UT) watershed. The following is a summary of the meeting objectives and attendance.

TAC Meeting. The TAC meeting was held in the Town of Blackstone, Virginia on October 21, 2003 to discuss the process for TMDL development. Representatives of various State and local government agencies and stakeholders attended this meeting. Copies of the presentation materials were available for public distribution. The meeting participants were contacted by DEQ via Email and phone.

Public Meeting No. 1. The first public meeting was held in the Town of Blackstone, Virginia on November 13, 2003 to present the following:

- the process for TMDL development
- the listed segment of Hurricane Branch (UT)
- data that caused the segment to be on the 303(d) list
- data and information needed for TMDL development
- preliminary findings regarding potential stressors

Copies of the presentation were available for public distribution. Nine people attended the meeting. The meeting was public noticed in the *Virginia Register*. During the 30-day comment period, no written comments were received by Virginia DEQ.

A draft stressor identification report was prepared and distributed to the TAC on February 3, 2004 for review and comments. Written comments via email were received and addressed by DEQ.

Public Meeting No. 2. The second public meeting was held in the Town of Blackstone, Virginia on March 2, 2004 to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft TMDL. Nine people attended the meeting. Copies of the presentation will be available for public distribution. The meeting was public noticed in the *Virginia Register*. Written comments via email were received and addressed by DEQ.

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